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THE PSYCHOLOGICAL REVIEW

NERVE PROCESS AND COGNITION

BY EDWARD CHACE TOLMAN

University of California

The fundamental importance of the problems of psycho-physiology would seem to warrant each sincere speculation concerning them. It is in this hope that the following argument is presented.

The attempt has been made to find a definition of cognition which naturally and of itself provides its own neurological explanation. Although the language of parallelism has been used throughout, this has been for convenience's sake only. I have not intended to prejudice arbitrarily the epistemological problem.

The definition of cognition which I offer is that it consists in a *placing of the given object or stimulus in some proper setting*. This was first suggested by a consideration of the question:—what would be objective (*i. e.*, behavioristic) evidence of cognition in another individual. Recent speculation[1] has advanced the proposition that the only sort of behavior on the part of a child which could be taken as proof positive of its consciousness of a given quality, for example, a color, would be behavior such as that exemplified in tests for color blindness. Professor de Laguna describes such behavior as involving "a *sorting* of the colored materials, an *arrangement* of them in a serial order. . . . Each tint or shade brings out a response appropriate to the specific character of the stimulus and characteristically different from the response demanded by every other tint or shade. The responses them-

[1] Grace A. de Laguna, *J. of Phil., Psychol., &c.*, 1916, 13, 533–547, 617–630.

selves form a series of graduated acts commensurate with the series of stimuli."[1] Such behavior involves, in short, a *placing* of the given quality with respect to others of its kind.

It will be my thesis that cognition always involves such a sorting or placing, but that the essential condition is an *internal neurological placing* rather than an overt objective one. For it is certain that one can and does cognize even when he is evincing no overt behavior. One knows himself to be aware of red on occasions when he is merely idly gazing at it and doing nothing objective with regard to it. This neurological placing, according to my theory, consists in an activity of association neurones which, under proper conditions, may lead to the objective sorting, but which can also go on without the latter.

Let us imagine a given colored light to cause a specific excitation in the visual areas of the cortex. This specific visual excitation we will assume tends to discharge into a specific association path. It will be the activity of this latter which, according to our theory, will constitute the sorting or placing, *i. e.*, the cognition of the given color. For we shall assume that the particular association path is what it is and derives its sole significance from the nature of its connections with other connected association paths. The path for red derives its significance from the nature of its connections with the paths for green and blue and yellow; while they in turn derive their character from the nature of their interconnections with one another and with the path for red. Similarly the specific path for the quality sour would derive its character from the nature of its connections with the paths for other taste qualities and so on.

To make such a hypothesis more cogent, let us attempt to work it out genetically in the case of an infant. We will suppose that, to begin with, the cortex of an infant is almost a *tabula rasa.* The stock of simple reflexes and instincts with which the child arrives into the world may be supposed for the most part to involve the lower centers only. Or, at any rate, we will assume that there is a large group of cortical

[1] *Op. cit.*, p. 545. (Italics mine.)

association neurones still undifferentiated. These undifferentiated cortical association neurones will offer the possibility of 'long circuit' connections between the same sensory and motor terminals more directly connected in subcortical regions by the reflex and instinctive equipment already on hand.

Now, let us imagine how specific paths may become developed in these hitherto undifferentiated 'long circuit' neurones. We will assume that, to begin with, every sense stimulus, in so far as its effect reaches the cortex at all, tends to dissipate its energies equally in all directions. All synaptic resistances are equal and there would be no tendency for any specificity of discharge in one direction more than in another. Consider, however, the effect which the repeated exercise of the reflex equipment may be supposed to have on such a condition. This reflex equipment contains characteristically different reactions for stimuli of different sense modes. Light causes eye movements, let us say, and pressure causes withdrawals of the part touched, and so on. Now, when one of these reflex acts is in progress, it means that any overflow of the stimulus which reaches the cortical levels will tend to go more directly toward the motor centers leading to that particular act than towards other motor centers. This follows upon an analogy with electrical circuits in parallel. And, as a result, different paths of low resistance through the association neurones will tend to be formed for the sensory centers corresponding to the different sense modes.

Consider now further the case of light. Imagine that a child is shown different colors, for example, red and yellow; and that when red is presented the nurse says 'red' and when yellow is presented, she says 'yellow.' We may suppose that the two colors produce different specific effects (spatial or chemical) in the visual area of the cortex. And we can assume, further, that there is a *reflex*, or perhaps *instinctive*, endowment whereby every sound has a tendency to arouse in the child an attempt at a vocal copy. Thus, accompanying the two different excitations in the visual area there will be (due to the activity of the lower centers) two different reflex

vocal accompaniments. As a consequence, we can expect that connected with each excitation a different specific path through the cortical association areas will tend to be formed. The visual processes corresponding to red will tend to become connected with the motor center for speaking the word red; the visual process for yellow with that for speaking the word yellow. We have already assumed, however, a single association path or group of association paths relatively open for all light stimuli: namely, paths leading to the motor centers for eye movements. We will now assume as an additional feature of our hypothesis that these new special groups of

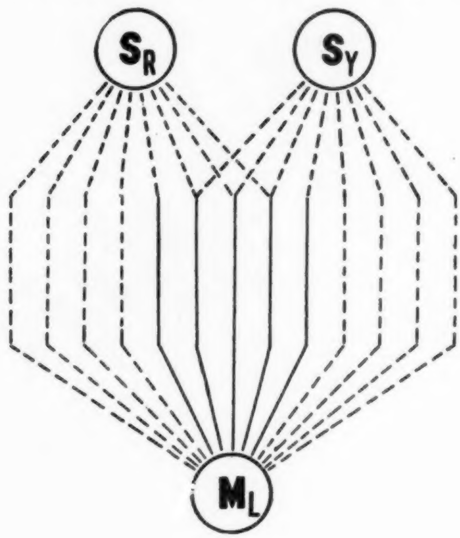

Fig. 1.

paths resulting from the speaking of 'red' and 'yellow' are influenced as to their direction by this already established group of general light paths. We can perhaps make this hypothesis clearer by means of diagrams (Figs. 1 and 2).

In Fig. 1, we represent the condition in which all light stimuli, of which red and yellow are examples, tend to go over into a single path (or rather group of paths), viz., that for eye movements. Thus S_r and S_y represent separate sensory cells (or separate chemical processes) corresponding to the

two colors. M_l represents the motor center or centers connected with eye movements. Both S_r and S_y can be conceived as connected with M_l by a very large number of possible paths (as shown by the solid lines and the dotted lines taken together). But however we envisage the difference between them, whether we think of S_r and S_y as different cells localized in different parts of the visual area, or as different physicochemical processes located within the same part, it may be assumed that some of the paths connecting S_r and S_y to M_l will be common (as shown by the solid lines). It is these common paths which will get developed as a result of the

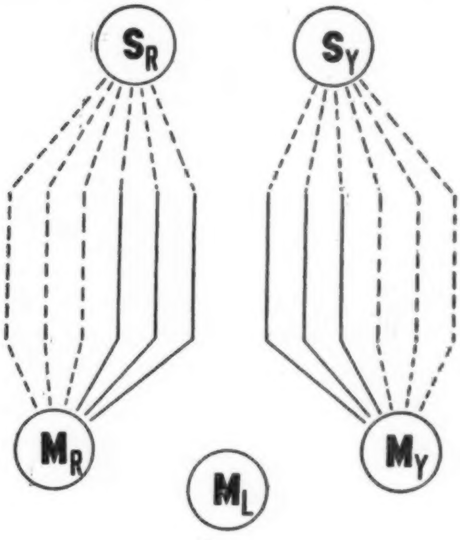

FIG. 2.

simple light stimuli and which will constitute the specific group of paths for light in general.

Suppose now that this common light path is achieved; how do the specific paths for red and yellow get developed? In Fig. 2 let M_r and M_y represent the motor centers connected with the vocalizations 'red' and 'yellow' respectively. S_r is connected with M_r by a great many different possible paths; and, similarly, S_y is connected with M_y by many different possible paths. Some of these in each case we may assume

would coincide for part of their length with the set of common paths used by both excitations in reaching M_l.[1] Since these latter are by hypothesis already well established, the resistance in them will be low. It seems reasonable to assume, therefore, that in the development of the new paths to M_r and M_y these old paths will to some extent be made use of; so that the final paths will take a course represented by the solid lines. As a result our final specific paths for red and yellow will be closely connected with the paths for light in general. (They will contain common elements with them.) They will also be closely connected with one another. In short, we will have the *beginning* of a system of paths, the activity of any one of which would constitute a *placing* of the object with respect to the system as a whole.

The objection may perhaps here be raised that the assumption of verbal instruction on the part of the nurse as a condition of learning to cognize the colors is unwarranted—that, in short, it is absurd to suppose that children must be taught to name colors before they can become aware of them. Now, as a matter of fact, I think it very probable that in a civilized community most children do learn colors as a result of being taught to name them. Still, if our theory is to hold water generally, it must allow for the savage or say the deaf mute, who learns colors without having words to express them. We shall lay it down as a general principle that, in such cases, the colors come to be discriminated only so far as they may serve as distinguishing marks for objects which otherwise tend to be confused. Suppose, for example, that a red sphere (apple) and a yellow sphere (ball) both originally cause the biting reaction in the child (as a result of reflex or instinctive endowment). Biting the ball, however, because of consequent discomfort, is followed by repulsion. Biting the apple, on the other hand, is followed by more biting. As a result, we may expect two different conditioned reflexes to be set up. Yellow sphere as stimulus will lead to something opposed to biting; red sphere as stimulus to reinforced biting. But the redness and the yellowness constitute,

[1] The paths going only to M_l are, for simplicity's sake, left out in Fig. 2.

by hypothesis, the only effective difference between the two stimuli. Here, therefore, just as in the previous example of repeating color names, we will have two different motor outlets set up for the two visual excitations of red and yellow. And we may suppose just as before that two different paths through the association areas will tend to be formed, one for red and one for yellow, and that the courses of these two paths will be influenced by an already established path for light in general.

A difference, however, between the end results is to be noted. In the case of learning the names, the 'red' and 'yellow' paths will finally terminate in motor centers for speaking red and yellow; in the present case, in motor centers for eating and repulsion. The final sets of paths would, therefore, hardly seem to be equivalent in the two cases. It is to be noted, however, that neither example claims to present a final picture. Before complete color perception can be achieved, many such occasions must occur. Red and yellow must be differentiated from one another in many different motor settings. They must also be presented with, and become similarly differentiated from, each and all of the other elementary colors. And as a result of each new occasion for differentiation new association paths will be formed. These new paths, however, will be influenced by, and will in turn influence, the already formed paths. Eventually, therefore, we may assume that only what might be called compromise paths will be left. There will be one group of these for each elementary color and every excitation corresponding to such a color will discharge for the first part of its course through such a compromise path, no matter what the motor center to which, under the conditions of the moment, it may ultimately lead.

This hypothesis resolves itself into three main points.

1. The constant and specific portion of each individual color path will be pushed back nearer to the sensory areas of the cortex and correspondingly further from the motor centers.

2. These constant and specific portions will simultaneously lose special connection with particular motor centers and will,

therefore, constitute compromise paths capable of leading equally readily to all motor centers.

3. The significance and the specificity of these compromise paths will consist in their relationships to one another and to the path for light, irrespective of color.

As a result of (3), the activity of any one such path will constitute the placing of the stimulus. If, for example, a given visual excitation discharges into the general light path, the stimulus will be seen (*i. e.*, placed) simply as light; if, on the other hand, it discharges into a specific color path, it will be seen (*i. e.*, placed) as a specific color. And similar systems of paths may be assumed to become developed for all the other types of sense qualities.

Before attempting to extend our hypothesis to objects other than sense qualities, let us here consider the theory as to the cognition of sense qualities developed by Bode.[1] The striking point of his theory is his definition of the function of consciousness as the *transference of the future into the present.* By way of illustration he uses, and emphasizes in particular, such qualities as 'sharp,' 'soft,' and the like. The "appearance . . . of a razor's edge as sharp is the sensory correlate of an incipient response which, if it were to attain full-blown perfection, would be the reaction to a cut. By hypothesis, however, the response is inhibited, and it is this inhibition which calls forth the perception of the object. If the response encountered no obstruction, adaptation would be complete and perception would not occur. Since there is a blocking of the response, nature resorts to a special device in order to overcome the difficulty, and this device consists in furnishing the organism with a new type of stimulus. The razor as perceived does not actually cut just now, but it bodies forth the quality 'will cut,' *i. e.*, the perceived attribute derives its character from what the object will, or may, do at a future time. That is, a perceived object is a stimulus which controls or directs the organism by results which have not yet occurred, but which will, or may, occur in the future

[1] Boyd H. Bode, 'Consciousness and Psychology' in *Creative Intelligence;* Henry Holt & Co., pp. 228–281.

. . . the future is transferred into the present so as to become effective in the guidance of behavior."[1]

The exact physiological mechanism by which this incipient motor response is supposed thus to body forth for consciousness a quality in the stimulus, is taken by Bode from Herrick,[2] one paragraph of whose discussion we may here requote:

"From the standpoint of the cerebral cortex considered as an essential part of the mechanism of higher conscious acts, every afferent stimulus, as we have seen, is to some extent affected by its passage through various subcortical association centers (*i. e.*, it carries a quale of central origin). But this same afferent impulse in its passage through the spinal cord and brain stem may, before reaching the cortex, discharge collateral impulses into the lower centers of reflex coördination, from which incipient (or even actually consummated) motor responses are discharged previous to the cortical reaction. These motor discharges may, through the 'back-stroke' action, in turn exert an influence upon the slower cortical reaction. Thus the lower reflex response may in a literal physiological sense act into the cortical stimulus complex and become an integral part of it."

Let us put this concretely into the case of Bode's razor. The razor, we are told, appears sharp because it calls out an inhibited subcortical tendency to react to it as to a cut. Let us think of this subcortical tendency as in the nature of a conditioned reflex.[3] We may suppose that in an earlier experience the razor actually did cut and that the reaction which instinctively or reflexly followed this cut (probably a dropping of the razor) became attached, because of the emotional intensity of the situation, to the razor itself as stimulus. This conditioned reflex, this dropping, is, however, by hypothesis inhibited; and it is the 'back-stroke' of this inhibited dropping which enters into the afferent impulse on its way to the cortex, and causes the quality 'sharp.'

[1] *Op. cit.*, p. 242.

[2] C. Judson Herrick, 'Some Reflections on the Origin and Significance of the Cerebral Cortex,' *Journal of Animal Behavior*, 1913, 3, 222–236.

[3] Bode does not himself suggest the term conditioned reflex, but I believe it to be what he means.

As thus stated, the theory seems striking and suggestive. Let us, however, examine it further. The conscious quality 'sharp' depends, we are told, upon two factors—an inhibited tendency to react as if to a cut, and the consequent 'back-stroke' effect going to the cortex. It is to be noted, however, that Bode does not fully explicate the function of the second of these two factors. The presence of the consciousness 'sharp' seems to depend primarily upon the presence and inhibition of the to-a-cut (dropping) reaction.[1] We are not told whether the going to the cortex of the 'back-stroke' of this inhibited reaction adds an essential or merely incidental factor to the production of consciousness. But if the addition of the cortical process is not itself an essential condition for the production of consciousness, then what is it which produces *conscious* awareness as opposed to a merely *unconscious* awareness? Bode does not explain how, as a result of frequent experience, one may come to treat a razor as sharp without having any *conscious* awareness of the sharpness as such. Obviously, however, such cases must be explained. If Bode's theory indicates any explanation for them at all, it would be that a direct subcortical effect of the inhibited dropping causes the *unconscious* treatment of the object as sharp, whereas the *cortical* effect of the inhibited dropping produces the *consciousness* 'sharp.' But, if such be the case, then our own theory is not so very far different. For in the instances of such qualities as 'sharp,' 'soft-appearing,' 'slippery-looking' and the like, we might readily admit that the 'back-stroke' from an inhibited motor tendency may constitute a necessary part of the afferent impulse coming to the cortex.[2] The essential thing is, however, that there would be no consciousness unless such 'back-stroke' does reach the cortex and hence by implication it is *something which happens in the cortex* which constitutes in the last analysis the ultimate source of consciousness.

Let us carry out our theory further in the case of 'sharp.'

[1] It is the inhibited to-a-cut reaction which 'transfers the future into the present.'

[2] We would not follow Bode, however, in extending such an assumption to all cases of cognition. It hardly seems a reasonable one in the cases of colors, tastes and other qualities which seem totally devoid of any inherent motor implications.

We would agree with Bode, and the functionalists in general, that consciousness usually arises in answer to a biological need. If, for instance, there were a tendency to treat the razor as both dull and sharp, then consciousness would be needed. At other times the shaving activity might very well go on without consciousness. A tendency to treat the razor as sharp means a conditioned reflex to drop the razor; while a tendency to treat it as dull means, let us say, a conditioned reflex to lay it down (originally the response to despair). Each of these two inhibited reflexes would affect the shaving activity in a different way, so that if both are present at once, there is trouble and the cortical activity is needed to settle between them.

Let us assume that the razor is really sharp. By hypothesis, however, the peculiar elements of the visual impulse, such as brightness and the like, connected with 'sharp' are not sufficiently strong for the appearance of the razor as a whole to produce subcortically the dropping tendency only. The laying down (dull) tendency is also excited, since the mere appearance of the razor in itself has become a major part of the stimulus for both dropping (sharp) and laying down (dull). A subcortical block from this conflict between the two tendencies results. The pure visual impulse reinforced by both 'back-strokes' goes up to the cortex. This is where the *logical* interrelationships of the cortical association paths prove their value. Logically a thing cannot be both sharp and dull, or, in other words, the interconnections of the 'sharp' and 'dull' association paths in the cortex must be assumed such that the activity of the one in like ratio inhibits that of the other. By hypothesis the purely visual part of the incoming impulse contained elements appropriate to sharpness only. But these will tend to excite the 'sharp' path and therefore to that extent to inhibit the 'dull' path. Hence the balance will be thrown on the side of the sharp. The 'back-stroke' of the inhibited laying down will not be equivalent to the 'back-stroke' of the inhibited dropping plus the purely visual elements. In the subcortical paths there was no such mutual exclusion of 'sharp' and 'dull' and hence

the mere sight of the razor could (before a nicety of association had been established) suggest both the sharp and dull reactions.

Once the cortical 'sharp' discharge is established, however, it tends (assuming the shaving activities still dominant) to go to motor centers which will reinforce the subcortical *effect* of the inhibited dropping; the subcortical block is broken and the razor is treated as sharp rather than as dull.

Finally, it should be noted that further experience with razors tends to make the initial tendency for a subcortical block less and less. The nicety of the subcortical associations becomes greater, so that the inhibited dropping reflex with its beneficial effect upon the shaving activities becomes more and more accurately attached to the visual excitation for sharp razors only, while the inhibited laying-down reflex becomes more and more attached to the visual excitation for dull razors only. When this state of affairs has been reached, there cease to be subcortical blocks, and, if the impulses happen to reach the cortex because of some chance low resistances, no particular advantage results therefrom. Consciousness in such a case is purely gratuitous.

Our divergence from Bode's theory may perhaps be summed up under the three following heads:

1. For many qualities, such as 'sharp,' 'soft-appearing,' 'slippery-looking,' and the like, the conception of a 'back-stroke' as forming an essential part of the afferent impulse finally arriving at the cortex, seems a reasonable hypothesis. For other qualities, apparently devoid of inherent motor implications, such as colors, tastes, odors, etc., it seems absurd.

2. Even supposing cognition always *did* involve inhibited incipient motor tendencies, the agency of such inhibited tendencies would be required for the successful unconscious reaction just as much as for the successful conscious reaction. Hence the presence of some further differentia would have to be assumed. Such a differentia is provided, we would suggest, by *our* theory of the associative placing which occurs in the cortex.

3. And finally, we disagree with Bode in so far as he seems

to imply that conscious perception never arises except in answer to a subcortical block. We would suggest that it may arise as the result of no motor dilemma whatsoever, but simply because the cortical resistances happen at the moment to be low.

We may now attempt to extend our own theory to other objects of cognition besides sense qualities. Consciousness is more often concerned with complex objects, such as chair, finance, and the like, than it is with simple sense qualities. We would assert that the awareness of such complex and abstract objects is also due to associative placing.

The consciousness of chair, for example, may be supposed to be correlated with the excitation of a specific group of paths which have developed in the association neurones as the result of experiences with chairs of many different sorts and in many different connections. Just as the specific cortical paths for the individual colors were supposed to develop as the result of instinctively and reflexly doing things with regard to colors, so the specific cortical path for chair may be supposed to develop as the result of the instinctive and reflex things which tend to be done with respect to chairs. In the case of chair, however, the number of different appropriate motor situations will probably be less than in the case of colors. Therefore, the specific association paths which will finally get developed for the idea chair will be nearer to the motor centers and more closely connected with them than we supposed to be the case for the paths developed for colors. The significance of such chair paths will consist, in part, in their relations to coördinate paths developed for the other kinds of furniture (table, bed, etc.), and in part, on their relations to the paths for various complexes of sense qualities (such as four-leggedness, seatness, backness, etc.).

In the case of finance, the situation would be similar. The specific path for this idea would likewise depend upon its connections with other specific paths, for example those for commerce, industry, and the like, as well as those for complexes of sense qualities, such as the appearance of dollar signs, office-desks, and so on.

The consciousness of red, of chair, and of finance would thus, by our theory, all be similarly conditioned. Each would depend upon the activity of a specific association path (or group of paths), and the significance of each such path or group of paths would consist in its relations to other specific paths or groups of paths.

In this connection, an essential feature of the theory appears. The aspect of cognitive consciousness which is thus *immediately* correlated with the specific association discharge is, according to us, a *meaning*. Sensation or image aspects may be present also, but meaning (in the sense in which we are using the term) is the thing essentially present. We will not attempt to give an introspective account of meaning. We merely insist that in real life, if not in the psychological laboratory, the meaning is always present and often the only thing present.

Our doctrine here will best be clarified by expanding it in detail for each of the three types of object: sense quality, chair, finance. In the case of the first, i. e., sense quality, the meaning will be simple. It might possibly be epitomized in verbal terms: 'this which I know as blue' (or whatever the quality happens to be). Correlated with such meaning, and accompanying it, there will be in addition the *quale* of the quality. By the *quale* of a quality, as distinct from its simple meaning, I would indicate the *raw feel*, which is present in both sensing and imaging, but lacking in 'unanschauliches' thought. The meaning, as has already been posited, is conditioned by the activity of a specific group of association neurones. The quale, or *raw feel*, we will now posit as conditioned by the sensory neurones which empty into these specific association neurones. It is to be noted, however, that, according to this theory, the sensory excitation will not produce a 'raw feel' unless it goes over into an association discharge. Introspectively this would mean that the 'raw feel' of a quality never stands alone, but always requires its accompanying meaning. The corresponding genetic doctrine would, of course, be that the child, no matter how developed its sensory neurones, does not become conscious of sense stimuli, until

it has acquired meanings for them[1] (*i. e.*, learned to discriminate them).

So much for the sensing of qualities. Let us turn now to the remembering or thinking of them. The latter processes apparently may or may not include a 'raw feel.' There seem to be some individuals who habitually, and others who occasionally, think of, or remember, a sense quality without any conscious imagery. In such case, meaning alone is present. The explanation in these cases would be provided by the assumption that the specific association neurones have connections not only with their own specific sensory centers, but, as a result of associations formed by experience, with one another and with other sensory centers. Hence they may (in associative thinking) be excited independently of their own sensory centers. In these cases consciousness may contain merely the corresponding meaning divorced from any accompanying 'feel.'

Let us now explain the cases in which the memory or thought of a quality does involve an image or 'raw feel.' Professor Washburn[2] has suggested that "the nervous basis of the centrally excited sensation might be a discharge of the nervous energies stored up in a sensory center, induced by the excitation, from some other source, of a motor pathway into which that center had formerly discharged." If we substitute for the idea of 'a motor pathway excited from some other source' that of a *specific association path excited from some other source*, this suggestion will serve us. For then we may assume that an excitation of a sensory center may be induced by the excitation from some other source (as the result of associative connections) of the specific association path into which that center usually discharges. When this happens, consciousness will contain the 'raw feel' (*i. e.*, an image) in addition to the mere meaning of the quality.

Turn now, secondly, to a consideration of the more complex cognitive object, of which chair is an example. Here again two cases are to be distinguished: (1) sense perception

[1] See in this connection Professor de Laguna's article quoted above.

[2] 'Mcvement and Mental Imagery,' footnote p. 31. See also article by same author, PSYCHOL. REV., 1914, 21, 376–390.

(2) memory and thought. In the former, the specific association path corresponding to the meaning is aroused by the externally initiated sensory excitements of color, shape, kinæsthetic feel, and the like. Our theory posits that these excitements go over (for the most part) into the common chair discharge rather than into their own specific quality discharges. Therefore it is chair as chair, rather than a mere collocation of sense qualities, which is perceived.

It may perhaps be objected that, in perceiving a chair, one is conscious not merely of the meaning chair, but also of individual sense qualities, such as brownness, shininess, and the like. This must be admitted. When I perceive that chair yonder, I perceive it not only as chair but as brown chair. The brownness constitutes an essential part of my perception. Our theory must assume, therefore, that in such a case, the sensory excitement produced by the brownness of the stimulus empties not only into the general chair discharge, but also in part into its own specific brown discharge. In such a case, furthermore, since there is both sensory excitement and meaning discharge for the quality brown, the 'raw feel' as well as the meaning of brown will be part of the total consciousness. A similar argument would, of course, hold for other sense qualities which may make up part of the conscious percept.

Consider, now, the case in which the chair is not presented in sensation but merely remembered or thought of. The remembering or thinking of the chair depends, we may assume, upon the excitation of the chair path as a result of associative connections. But this path is usually touched off in sensation by a constant set of sensory activities such as those derived from the visual appearance of four-leggedness, the kinæsthetic feel of sitting, and so on. Such being the case, we may assume, just as we did for the simple sense qualities, that the associative excitation of the meaning path may arouse sympathetically those sensory centers usually emptying into it. If such a process happens and if further *these sympathetically aroused sensory centers then begin emptying also into their own specific quality discharges*, the subject will ex-

perience imagery in connection with his thought or memory. Different individuals may be supposed to differ in the extent to which their nervous systems are prone to this sympathetic arousal of the sensory centers and also, perhaps, in the extent to which such arousals then tend to go over into their specific quality discharges. The person in whom imagery is frequent would be one in whom such phenomena occur readily.

An interesting digression may here be made as regards the probable nature of introspection. The assumptions just preceding would suggest that introspection may involve primarily nothing more than the obtaining of specific quality discharges for sensory excitements which otherwise tend only to go over into more general discharges (such as the chair discharge in the above example). In the remembering or thinking of a chair, the chair meaning functions ordinarily for most individuals without *conscious* imagery. One has to be 'trained to introspect' before one finds much imagery, and then it is only by stopping and thinking back that one discovers it. It will be our contention that in such cases the imagery *really is not* present till one thinks back for it. The chair path or paths are excited; but it is not until one introspects that a sympathetic arousal of the sensory centers goes over into the specific quality discharges and one becomes aware of images.

The question may be raised how such a shunting of the sensory excitations into their simple meaning paths is accomplished. The answer would be that one has been taught to introspect; that is, one goes at his introspective task with various thoughts present as regards the kind of sensations and images he is to look for. In physiological terms, this means that there is a preliminary excitation of the simple quality paths. This lowers their synaptic resistance and sets them in readiness, so that *then* the sympathetically excited sensory centers more readily discharge into them.

But introspection is invoked not only for cases of memory and thought, but also for sense perception. Thus one might be set the task of introspecting one's visual perception of a chair. When not introspecting, one's perception of a chair

would seem often to consist of hardly more than the meanings chair, brownness, over there, etc., plus the 'raw feel' of the brownness and of the 'over-there-ness.' If one is asked to introspect, however, one becomes aware of many other sensory factors; various kinæsthetic feels, organic sensations of relaxation as in sitting, eye-strain, patches of white and black as well as of brown, auditory kinæsthesis for word, chair, and so on and so on. Till asked to introspect, these things were not present to consciousness. Our explanation is that the sensory excitations corresponding to these various sensations, which introspection brings to light, were, previous to introspection, simply emptying into and reinforcing the chairness, brownness, and over-there-ness discharges. The introspective attitude sets in readiness paths specific for these sensory qualities; whereupon the sensory excitements discharge into such paths and the qualities themselves enter consciousness.

Turning, finally, to the third type of object, the idea finance, little remains to be said. The situation is similar to that for chair. The difference is that in the case of finance the connections between the general meaning and specific sense qualities are more variable and dependent upon individual association than is true for chair. As in the case of the latter, however, the general meaning path may be set off by actual sensory excitations (in this case words) or as the result of associative thinking. And introspection will have the same task to perform in causing specific meaning discharges for sensory excitations which otherwise pass over into a general meaning discharge only.

Let us draw attention to the difference which our theory would posit between the consciousness of particulars and of universals. Meanings such as red, chair, and finance are universals. What is it then which constitutes the differentia of the consciousness of a particular red or of a particular chair? It might seem, at first, as if my perception of yonder chair as a particular depended, at least in part, upon the fact that it is a chair of a particular brownness, and hence upon the fact that in addition to the simple chair meaning I have the brown meaning. The particularity would, on this

hypothesis, be due to the fact of the presence of more than one universal meaning in combination. But a little further thought shows such a hypothesis to be inadequate. Yonder brown chair may be but one of a whole series of chairs all turned out by the same factory and all alike. Its particularity cannot, therefore, consist in its brownness combined with its chairness nor in any other mere concatenation of meanings. The one thing left to serve as the cause of its particularity is the fact of its yonderness, *i. e.*, the fact that it has a particular spatial and temporal meaning. A particular is a particular by virtue of its location in the temporal order or, in the case of a material thing, in both spatial and temporal orders. When, therefore, one is conscious of a particular, as opposed to a universal, our theory posits the presence of a temporal and perhaps also a spatial meaning in addition to other meanings.

Just how, in detail, the systems of association discharges corresponding to these spatial and temporal meanings are to be conceived would be a question which we will not here attempt to answer. It may be asserted, however, that whatever the details of the processes, they probably develop in ways analogous to that which we assumed for the development of the paths for the simple qualities, such as color. We may assume that different reflex and instinctive acts are performed as a result of different spatial and temporal relationships, just as they are performed as a result of different qualities or different concrete objects. We may suppose that cortical association paths develop in parallel with these subcortical reflex and instinctive processes. Furthermore, we would be inclined to assume that in the cases of these temporal and spatial objects Bode's hypothesis holds. We suggested that it probably did hold in the cases of such qualities as sharp, slippery-looking, and the like which seem to have motor implications. It seems, therefore, reasonable to assume that it holds also in the cases of spatial and temporal objects. For they certainly have motor implications. The whole accepted psychology of space perception has been concerned with indicating the importance of incipient motor responses

such as those of eye-movements, head-turnings, hand-reachings, and the like. The psychology of time perception is less developed; but, even there, the evidence points towards an importance of motor processes, such for example as those of breathing, beating time, and the like. We conclude, in short, that the effective afferent impulses arriving at the cortex which go over into the specific spatial and temporal meaning discharges probably contain as essential elements the 'back-stroke' action of inhibited subcortical processes.

In conclusion, we may sum up the significant features of our whole theory as follows:

1. Cognition consists in a placing of the given object or stimulus in a setting.

2. This placing consists neurologically in the *activity* of a specific path in the association neurones. Such a specific path owes its specificity to its interrelationships with other similarly specific paths for related objects.

3. The subjective aspect of cognition (*i. e.*, that which according to our theory is correlated with the activity of the specific association path) is a *meaning*. (No introspective account of the nature of meaning has been attempted.)

4. The essential cognitive experience is equally a meaning, whether the object cognized be a sense quality, a complex of sense qualities or an abstract idea. In the case of sense qualities, however, there may be in addition to the meaning a 'raw feel' (*i. e.*, if the quality is either actually presented to the sense organs or is present as an image). These 'raw feels' arise in connection with the activities of the sensory centers. They only appear, however, if there are corresponding association discharges, that is, if the corresponding meanings are also present.

EXPERIMENTS IN RATIONAL LEARNING

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Introductory

The study here reported stands midway between experiments on learning and intelligence tests. Most of the experiments that have been carried out on learning deal with practice effects that are in the main uninfluenced by rational behavior —such as typewriting, telegraphy, ball tossing, distribution of cards, segregation of wads, substitutions, discrimination of various sorts, memorizing nonsense syllables, and so on. Usually methods of procedure are rather clearly outlined to the subject in the instructions. Some of these learning processes are clearly concerned only with the acquirement of skill, little organization or conscious selection of any sort being required.[1]

Another type of learning has to do largely with the mastery of puzzles, problem boxes and mazes.[2] In some of these cases the situation remains unchanged in its essential features during the attempts at the solution of the problem; in others the situation to which the learner is reacting changes with the different reactions. In this general group of problems one successful solution may be sufficient to reveal the steps to be taken, so that subsequent efforts are practically perfect,

[1] E. g., E. L. Thorndike, 'The Psychology of Learning,' 1913. W. Brown, 'Habit and Interference in Sorting Cards,' *Univ. of California Pub. in Psychol.*, Vol. I, No. 4, 1914. H. Woodrow, 'Practice and Transference in Normal and Feeble-Minded Children,' *J. Educ. Psychol.*, 1917, **8**, 85–96 and 151–165. J. Peterson, 'Experiments in Ball-Tossing: The Significance of Learning Curves,' J. Exp. Psychol., 1917, **2**, 178–224. W. H. Batson, 'Acquisition of Skill,' Psychol. Monog. No. 91, 1917.

[2] E. g., E. H. Lindsley, 'A Study of Puzzles with Special Reference to the Psychology of Mental Adaptation,' *Amer. J. Psychol.*, 1897, **8**, 431-493. H. A. Ruger, 'The Psychology of Efficiency,' *Archiv. of Psychol.*, No. 15, 1910. J. H. Ballard, 'Some Phases of the Psychology of Puzzle Learning,' 1915(?). V. C. Hicks and H. A. Carr, 'Human Reactions in a Maze,' *J. Animal Behav.*, 1912, **2**, 98–125. F. A. C. Perrin, 'An Experimental and Introspective Study of the Human Learning Process in a Maze,' Psychol. Mon., No. 70, 1914.

or the relations may be so intricate as to require a series of successive trials for a perfect score. In mazes, for instance, the situation is often so baffling as to prevent at first the use of reason; the cues are so numerous that they cannot all be reacted to together or be held in mind by a person until after several repetitions have been made. A mental picture of the situation in its larger aspects may thus for a time be impossible, and the readiness of its establishment may depend to a considerable extent on the initiative of the learner.

Experiments on animals early aimed to incorporate some sort of more or less vaguely conceived rational or ideational element. Lloyd Morgan's idea of learning by trial and error answered the contention of Darwin, Romanes, et al. that animals reason, but a number of careful experiments were naturally to follow. Thorndike had animals react to various problem boxes, and found that the evidence was against the existence of reason and the use of ideas in such behavior.[1] The 'gradual slope' in the time curves he took to indicate 'the wearing smooth of a path in the brain, not the decision of a rational consciousness.' Hobhouse devised various tests which he contended required for their solution something more than mere association. Animals, he argued at length, showed 'practical judgment,' reactions based on the perception of relations among concrete objects, or on the perception of results affecting themselves. The experiments required reactions to several things simultaneously stimulating the animal, it was supposed, and they were devised to require some sort of conscious selection based on an anticipation of the results to be obtained. He admitted, however, that his results in the main were unfavorable to the existence in animals of ideas and of reflective imitation.[2] The multiple choice method of Yerkes, whose beginnings are to be found in Kinnaman's[3] and Hamilton's[4] works, was specifically designed, it

[1] These studies are now all published in book form, 'Animal Intelligence,' 1911.

[2] L. T. Hobhouse, 'Mind in Evolution,' 1901.

[3] A. J. Kinnamon, 'Mental Life of two *Macacus rhesus* Monkeys in Captivity,' *Amer. J. Psychol.*, 1902, **13**, pp. 98–148 and 173–218.

[4] G. V. Hamilton, 'A Study of Trial and Error Reactions in Mammals,' *J. of Animal Behav.*, 1911, **1**, 33 ff.; also 'A Study of Perseverance Reactions in Primates and Rodents, *Behav. Mon.*, No. 13, 1916.

appears, to present a situation that could not be solved by mere contiguity association. Certain results of this method have been interpreted by Yerkes as possibly showing ideation in the behavior of an orang-utan.[1]

A present tendency in psychology, not to be exactly identified with behaviorism, is putting the emphasis on mere contiguous association—after the order of the conditioned reflex of Pawlow and the associated- or psycho-reflex of von Bechterew—as possibly the only principle of learning, vividness and recency being used to supplement the frequency of the contiguity.[2] The operation of the vividness principle is, however, in most cases somewhat vaguely conceived. In fact, when we come to neural explanations it must be confessed that we are yet groping in ignorance. It is extremely difficult to conceive how elimination of useless movements is possible at all. The difficulties have been briefly indicated by the writer, among others, and he has shown that the maze learning of rats does not follow recency-frequency expectations at all, though these principles are not without influence, but that such learning *must at first, and actually does in the first trials by the animal, go contrary to these principles as at present understood.*[3] Further studies on humans by means of what is being called a mental maze are to follow.

The Problem

Our present study, though an outgrowth of these investigations, approaches the general problem of factors in learning from another angle. It was suggested to the writer in going over the recent studies of Hamilton and Yerkes, particularly in considering the significance of perseverance reactions (Ham-

[1] R. M. Yerkes, 'The Mental Life of Monkeys and Apes: A Study in Ideational Behavior,' *Behav. Mon.* No. 12, 1916. References are given to other studies by the multiple choice method.

[2] This tendency is, of course, not a new one in psychology, but it is based more definitely on experimental evidence. Though the experiments themselves are somewhat limited in their direct application, it is tempting to extend theoretically their significance.

[3] 'Completeness of Response as an Explanation Principle in Learning,' Psychol. Rev., 1916, 23, 153-162; 'Frequency and Recency Factors in Maze Learning by White Rats,' *J. Animal Behav.*, 1917, 7, 338–364. Other references there given.

ilton). A sort of choice-reaction problem is presented to the human subject, about whose possession of relevant ideas and of rational ability there is no doubt. It is our special purpose to see how rational learning is related to learning that must depend wholly on 'trial and error' efforts. How effectively are ideas used in a type of learning in which their employment is obviously helpful?[1] The reaction required of the subject is to associate in a random order the numbers 1 to 10, inclusive, with the first ten letters of the alphabet. This is to be done by means of a series of guesses the range of which may be greatly limited by the use of a rational organization of the situation. Each subject completes the learning at a single practice period, varying in length inversely with the subject's ability, roughly speaking. As will be seen, the subject is forced to react to a changing situation, each response making it different to a slight degree by limiting the range of probability.

The Method

The experimenter in giving the 'tests,' as they were called in talking about them to the subjects, sat at a table opposite the subject shielded from the view of the latter by a screen. The experiments were carried out in a quiet room by the writer. The following instructions were given each subject:

"This is a memory-reason test. The letters *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *I*, and *J* are numbered in a random order from 1 to 10. I call out the letters in their order and you are to guess numbers for each letter till you get the correct number, when I say 'Right.' Then I call out the next letter, and so on. This is continued till you get each number right the first guess twice in succession through the series, from *A* to *J*. Then you are through. *You must ask no questions*, but are to use all the mental powers at your command. You will be judged by the number of errors (or wrong guesses) you make and the number of repetitions from *A* to *J* required."

The subject was left free to use any method in establishing the associations, that occurred to him. Nothing was said

[1] For an objective conception of 'idea' see an article by the writer in Psychol. Rev., 1918, 25, pp. 214–226.

regarding introspection, though some of the subjects volunteered information of an introspective nature after the experiment was completed, and others were questioned about certain irregularities noted in their behavior and about matters on the interpretation of which the experimenter desired more light. Such questions were in every case asked immediately after the completion of the experiment. Specific cases will be given later. The lack of systematic introspection is justified by the fact that a rather complete record of the subject's reactions was made, and also by the desirability of having no disturbing factors enter into the learning process. The objective record was in many cases found to be much more reliable than the subject's memory, regarding the clearness with which certain elements had been held in mind.

All the subject's relevant reactions were accurately and easily recorded. The method is objectively shown in Table I. The letter *A* was first called out and each of the subject's guesses was recorded, in order, under *A*. Hesitancy or extreme deliberation was usually indicated by a certain mark. At first the subject would usually guess only one number and then wait till he was told to proceed as instructed. When the correct number, 9, was guessed the experimenter would say *right!* and call out the next letter, *B*, and so on. When all letters to *J*, inclusive, had been completed, *A* was immediately called again without any interruption. After the first series each successive letter was usually called as soon as the correct number of the one preceding it was given, and the response *right!* by the experimenter, now unnecessary, was omitted.

The subject not infrequently guessed a number and quickly corrected it; as, "6; no, 7," or "6; no, I guessed that for *B;* 8." In all such cases the number thus clearly spoken and retracted was, however, recorded as a guess. It often happened that the subject would begin saying some number, as 'sev—' for seven, and not complete it. A reaction of this kind was not recorded as a guess although it was frequently evident which number was in mind. Such reactions were, however, indicated, though not with entire regularity in the beginning of the experiment. It was later noticed

that they might have considerable significance and throw light on the nature of the learning. In regard to this type of behavior different subjects showed marked differences; some would think the whole process out before speaking the number, while others were inclined to do more or less of their thinking aloud. A number of them employed their fingers in various ways, while others, as they explained later, attempted to associate the forms of the related figures and letters. No particular method seems to have universal advantage, or to be related to marked success or lack of success, though this matter may well be left open for special study.

The Subjects

The subjects are described individually on a later page. All were adults but one. Special training in the observation of one's own mental processes was not desired in this case, the purpose being only to get persons of ordinary rational capacity. Some of the subjects had had a number of courses in psychology.

Results

The results of each individual have been tabulated for special study. The presentation and analysis of a few typical cases is essential here, even at the expense of a discussion of the relation of rational to other learning. Table I is the record of a junior college man of fair mental ability, probably slightly above the average in his section.

In this record every reaction is shown in its order of occurrence. It is interesting to note that the greatest number of errors is made with the letters at the middle of the series, *i. e.*, with *D*, *E*, and *F*. But for an obvious confusion in connection with *I* and *J* in the 5th, 6th and 8th series, there would have been an almost symmetrical sloping in the total unclassified errors at the base of the table, toward the *A*- and the *J*-end of the series. The first letters of the series seem to have a much better memory-value position than the later ones, despite the fact that in the early repetitions through the series the possible minimizing of errors through a logical limitation of the number to be guessed was gradually increased toward *J*. In

TABLE I

RECORD OF MR. A. B., JUNIOR COLLEGE MAN

Letters	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	Errors			
Numbers	9	6	2	10	8	1	5	4	7	3	Unclassified	x	*	Total
First series (or trials)	3 4 5 6 9	4 6	5 7 3 1 2	7 10	4 2x 1 6x 9x 7 3 5 4 10x 8	4 3 7 10x 5 3* 1	3 7 4 5	1x 7 3 6x 7* 4	1x 7	1x 3	36	9	2	47
Second series	9	4 2 3 6	2	5 4 7 9x 10	7 4 1 5 2x 6x 7* 8	5 6x 3 1	9x 10x 7 4 3 5	3 2x 1x 9x 6x 5x 8x 9x* 4	10x 3 7	3	32	14	2	48
Third series	9	5 7 2 4 6	2	5 8 9x 4 1 6x 9x* 7 3 5* 8* 10	7 5 2x 4 6x 1 3 5* 8	5 2x 4 9x 7 6x 5* 4* 3 1	6x 2x 4 8 9x 7 5	3 7 4	3 5x 6x 7	3	43	13	6	62
Fourth series	9	6	2	5 7 4 6x 1 3 10	4 1 7 8	4 3 1	7 5	4	3 7	4x 3	14	2	0	16
Fifth series	9	6	2	10	8	1	5	4	1x 5x 9x 7	3	3	3	0	6
Sixth series	9	6	2	10	8	1	5	4	7	1x 6x 9x 7x 5x 4x 3	6	6	0	12

TABLE I—*Continued*

Letters / Numbers	*A* 9	*B* 6	*C* 2	*D* 10	*E* 8	*F* 1	*G* 5	*H* 4	*I* 7	*J* 3	Errors: Unclassified	Errors: x	Errors: *	Errors: Total
Seventh series	9	6	2	10	8	1	5	4	7	3	0	0	0	0
Eighth series	9	6	2	10	8	1	5	4	3 9x 2x 7	2x 9x 4x 6x 8x 9x* 3	9	8	1	18
Ninth series	9	6	2	10	8	1	5	4	7	3	0	0	0	0
Tenth series	9	6	8 10 2	10	6x 1 2x 8	1	5	4	7	3	5	2	0	7
Eleventh and twelfth series correct														
Total U.C. Errors	4	8	6	22	31	20	15	15	13	14	148			
x Errors	0	0	0	5	10	5	5	9	9	14		57		
* Errors	0	0	0	3	2	3	0	2	0	1			11	
Totals	4	8	6	30	43	28	20	26	22	29				216

other words, the guessing of *A* in the first series was by pure chance, its probability of correctness in the first trial being 1 to 9; that of *B* (if strict logic and perfect memory were employed) was limited by the subtraction of the used number, 9, and would be 1 to 8; that of *C*, 1 to 7; and the probabilities of a correct guess the first time under these conditions would be 1 to 6, 1 to 5, 1 to 4, 1 to 3, 1 to 2, 1 to 1, and 1 to 0, respectively for *D*, *E*, *F*, *G*, *H*, *I*, and *J*. With perfect logic and memory *J* would always be correct, and all guesses in subsequent series would always be correct. Our subject, A.B., falls far short of such perfection! He was definitely warned that "this is a memory-reason test," and was advised to use all the mental powers at his command. He continued to make frequent errors, even in the 5th, 6th, and 8th series on the letters *I* and *J*, when every error made consisted in naming

for these letters numbers which he *knew* belonged to other letters and which could therefore not be right for these cases. This statement he himself admitted, after the experiment was completed. The errors were made because under the conditions he 'didn't think of it.' Such a reaction proved to be by no means peculiar to this subject, showing that in the stress of a difficulty, not at all different from many that one must constantly meet in practical life, one's reactions may become limited to a suprisingly narrow aspect of the situation, or, in subjective terms, consciousness becomes thus limited.

We have classified the errors into three kinds: (1) unclassified, (2) logical, (3) and perseverative. The first needs no further explanation. The *logical errors* are those indicated in the table by an *x*, and consist in guessing a number that has already been used for an earlier letter of the series, one that could therefore not possibly be correct. It is, of course, true that not only bad logic but bad memory is responsible for such an error; in fact, the error may occur, and frequently does occur, when the subject would know perfectly well on a little thought that it is wrong, as has already been indicated. In one sense, as we have pointed out, all errors in the second and subsequent series are logical errors as the term is here defined; but we have chosen to make the arbitrary limitation here described, because the subject has a decided sense of getting back to the starting place when the first series is completed. *Perseverative errors* are errors of repeating a wrong guess while reacting to a single letter. In Table I such errors have been indicated by an asterisk (*). Since this is a study of rational learning, and such errors are more serious than those made without the possibility of logical inference, it has seemed desirable to count an extra point against the subject for each logical or perseverative error, and two extra points if any guess is both a logical and a perseverative error. The errors for *I* and *J* in the 5th, 6th and 8th series, for example, are more serious than those for *A*, *B*, *C*, and *D* in the first series—in this case many times more serious, perhaps, but we have had to adopt some sort of practicable classification for errors of different kinds. Such arbitrary limita-

tions and distinctions must always be given under circumstances similar to these, and this is one source of fallibility in all intelligence tests.

It is obvious that our subject has made a number of logical and perseverative errors that are due to thoughtlessness and that could have been avoided with sufficient care. Often, as we might expect, such errors were due to emotional excitement under competitive conditions, each student being anxious to stand comparatively high in the tests. In many cases they were clearly due to too much attention to one particular aspect of the situation to the neglect of other relations. Differences in this respect seemed to be particularly due to (possibly innate) differences in mentality, a matter to be considered in later pages.

Two other records, which it seems worth the space to consider separately, will show different methods of such limitation of attention, while one record that is almost logically perfect will illustrate the advantage of reacting to a wider range of the essential or conditioning factors.

Table II gives the record of Mr. L. D., a sophomore student who ranked in work in the psychology class with the best fourth of the students. This subject failed to react to all the significant factors in the situation because he was, in a sort of random way, looking for some regular order in numbering. At first he reacted so slowly that occasionally he would sit in a sort of stupor between each response. As a consequence of this he often repeated a number (perseverative reaction) because he had forgotten what numbers he had already guessed for the letter in question.[1] He suddenly made great improvement, however, when he gave up the futile search for some principle in the numbering. After the experiment he reported as follows: "I hadn't at first formulated any plan, but tried to remember without any organization; was alert for any scheme or regular design in the numbering. Then I tried to remember the correct numbers in their true order of sequence, with little attention to the

[1] To prevent this condition the instructions to subjects in later experiments, subjects not included in the present group, name time as one of the criteria of efficiency.

Table II

Record of Mr. L. D., a Sophomore Student

Letters .... Numbers	*A* 9	*B* 6	*C* 2	*D* 10	*E* 8	*F* 1	*G* 5	*H* 4	*I* 7	*J* 3	Errors			
											Unclassified	x	*	Total
First series	3 5 1 2 9	8 7 10 3 1 6	5 3 1 7 10 9x 4 2	5 7 10	8	7 5 4 1	10x 3 5	10x 3 1x 7 6x 9x 2x 7* 9x* 2x* 4	5x 3 7	3	35	10	3	48
Second series	2 6 8 4 1 9	6	10 9x 2	9x 7 10	7 9x 8	7 5 3 9x 1	7 3 5	5x 9x 7 5x* 7* 9x* 10x 6x 9x* 6x* 4	7	9x 10x 6x 8x 2x 1x 3	33	18	5	56
Third series	8 6 9	2 4 8 10 1 7 8* 6	10 1 8 6x 3 7 5 8* 6x* 5* 4 10* 2	10	7 5 3 1 8	1	7 3 4 2x 5	4	3 7	3	30	3	5	38
Fourth series	9	6	2	10	8	1	5	4	7	3	0	0	0	0
Fifth series	9	6	1 8 2	10	8	1	5	4	7	3	2	0	0	2
Sixth and seventh series correct														
U.C. Errors	11	12	23	4	6	7	8	20	3	6	100			
x Errors	0	0	4	1	1	1	2	15	1	6		31		
* Errors	0	1	4	0	0	0	0	8	0	0			13	
Totals	11	13	31	5	7	8	10	43	4	12				144

particular letters associated with them." He evidently tried to disregard, or to exclude from attention, all his wrong guesses and to hold only the right ones. This principle was adopted in the third series, and the results show themselves in the fourth. In this case, then, we should get a sudden drop in the error curve of learning due to the adoption of this efficient idea. From this point on pure mechanical memory must do the rest, within the range set for it.

A somewhat similar but less mechanical procedure was

TABLE III

RECORD OF MISS A. R., A GRADUATE STUDENT

Letters Numbers	*A* 9	*B* 6	*C* 2	*D* 10	*E* 8	*F* 1	*G* 5	*H* 4	*I* 7	*J* 3	Errors			
											Unclassified	x	*	Total
First series	10 9	10 9x 8 7 6	10 9x 8 7 6x 5 4 3 2	1 2x 3 4 5 6x 7 8 9x 10	1 2x 3 4 5 6x 7 8	1	1x 2x 3 4 5	1x 2x 3 4	1x 2x 3 4x 5x 6x 7	1x 2x 3	44	19	0	63
Second series	9	6	2	8 10	8	1	5	4	7	3	1	0	0	1
Third series	9	6	2	8 10	8	1	5	4	10x 7	3	2	1	0	3
Fourth series	10 9	6	2	8 10	8	1	5	4	7	3	2	0	0	2
Fifth series	9	6	2	8 10	8	1	5	4	7	2x 3	2	1	0	3
Sixth series	9	6	2	10	8	1	5	4	7	3	0	0	0	0
Seventh series	9	6	2	10	8	7 1	5	4	7	3	1	0	0	1
Eighth and ninth series correct														
U.C. Errors	2	4	8	13	7	1	4	3	7	3	52			
x Errors	0	1	2	3	2	0	2	2	6	3		21		
* Errors	0	0	0	0	0	0	0	0	0	0			0	
Totals	2	5	10	16	9	1	6	5	13	6				73

TABLE IV

MR. L. E., A UNIVERSITY PROFESSOR

Letters Numbers	A 9	B 6	C 2	D 10	E 8	F 1	G 5	H 4	I 7	J 3	Errors Unclassified	 x	 *	 Total
First series	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6	5 4 3 2	1 3 4 8 10	1 3 4 5 7 6x 9x 10x 8	1	3 4 5	4	3 7	3	31	3	0	34
Second series	9	7 6	2	10	3 1 4 7 5 8	3 1	5	4	3 7	3	8	0	0	8
Third series	9	6	2	8 10	7 5 4 8	1	7 5	4	7	3	5	0	0	5
Fourth series	1 9	6	2	10	1 8	1	5	4	7	3	2	0	0	2
Fifth series	9	6	10 2	10	8	1	5	4	7	3	1	0	0	1
Sixth and seventh series correct														
U.C. Errors	9	6	4	5	17	1	3	0	2	0	47			
x Errors	0	0	0	0	3	0	0	0	0	0		3		
* Errors	0	0	0	0	0	0	0	0	0	0			0	
Totals	9	6	4	5	20	1	3	0	2	0				50

adopted by the subject Miss A. R., a graduate student. She succeeded in the first series in finding a rational order in the numbers, but likewise wholly disregarded at the same time the possible minimizing of errors by avoiding the guessing of numbers already used. So while the limitation of attention in one sense aided the learning, in another it failed to prevent a certain kind of important errors. The procedure was therefore not highly efficient. At the end of the experiment Miss A. R. reported that she noted this order: "9, 6,

2,—beginning with 9 the numbers decrease by three, except that 2 is one step too low; then come 10 and 8, two less, and 1, the smallest number; 5, the next, is always easy to remember, and 4, one less, follows. I learned 7 and 3 directly." This scheme, however, did not prevent continued errors on numbers thus rationally arranged. Note, for instance, the four-times-repeated error of guessing 8 for 10 with *D*. Evidently the rationalization must not have occurred all at the first series, but gradually. The result was a large number of series with comparatively few errors. It should be noted, however, that the methods used by L. D. and A. R. give a high proportion of logical errors.

A. R. made no perseverative errors. This is due to the fact that while looking for the relations of the successive numbers, already pointed out, she followed rationally in the first random guesses, the definite order either of beginning with 1 and numbering up in order, or, taking the reverse course, of beginning with 10. She therefore followed a more thoroughly rational order than did L. D. and made fewer errors; but she allowed attention to be distracted from another useful point—that of leaving out, in this definite order of procedure with each letter, numbers already used with preceding letters. She continued to repeat, after using them, 9, 6, 2, and so on.

This particular precaution was taken by the final illustrative case we shall consider, along with the other precaution of guessing from 1 upward in the number series with each letter. Mr. L. E., the subject, is a university professor of good native ability and very careful logical training. The entire situation was, however, not grasped in the first series, and as a consequence three logical errors occur in the guessing of the number of *E*. After this point the mastery of the problem was wholly one of memory, the logical situation having been grasped and kept in mind; and the field for memory to master was greatly limited so that the problem was soon solved. Little slips of memory, however, made necessary seven repetition series for the solution of the problem as defined. In this case we have a small proportion of logical errors to

total errors, and also a relatively small proportion of logical errors to the total number of repetition series required. Only one student excelled L. E.'s record, and this happened to be the only high school student in our present group, a boy of an abnormally high intelligence quotient (IQ = 1.45). This subject, R. B., however, made twice as many logical errors as L. E., therefore excelling him only in retention.

It is very difficult to lay down any definite rule as to the best logical procedure in a problem of this kind, for many of the best subjects follow original plans of their own. Thus the subject with fewest errors of all, R. B., neglected the rule to guess in order from 1 to 10 but just struck out in any order. The problem seemed to be so simple for him that he kept the situation well enough in mind so as not to make any perseverative errors. It is possible that by following the numerical order in the guessing, he would have been freer to avoid logical errors, as was the case with L. E. On a harder problem, *i. e.*, one with, say, twenty or more letters, the advantage of such a procedure would probably have shown itself perceptibly.

We shall now present tables of the results of all the subjects in the first group of our experiment, subjects who were not definitely told that time would be a criterion in judging of their efficiency. These tables include also the results already considered individually. Time considerations were omitted in order that the subjects might not feel under too much pressure for the amount of deliberation that they would naturally be inclined to make. A separate report will give the results of subjects encouraged to complete the learning in as little time as possible.

Table V gives the summarized results of nineteen subjects classified as follows: Two university instructors, two graduate students, ten college students, one high school student, and four other adults,—one electrical engineer, one doctor, one woman of 50 years who had completed part of a high school course, and one bond clerk, a high school graduate. The instructors are L. E. and L. H.; the graduate students are A. R. and P. N.; R. B. is the high school student; and the

Table V

Errors in Successive Series

Subject	1st			2d			3d			4th			5th			6th			7th			8th			9th		
	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P
A. B.	36	9	3	32	14	2	43	13	5	14	2	0	3	3	0	6	6	0	0	0	0	9	8	1	0	0	0
L. D.	35	10	3	33	18	5	30	3	5	0	0	0	2	0	0	...	...	...	...	...	...	...	...	...	...	...	...
A. R.*	44	19	0	1	0	0	2	1	0	2	0	0	2	1	0	0	0	0	1	0	0	...	...	...	...	...	...
L. E.	31	3	0	8	0	0	5	0	0	2	0	0	1	0	0	...	...	...	...	...	...	...	...	...	...	...	...
T. R.*	33	10	1	22	15	5	7	1	0	20	2	2	4	2	0	1	0	0	0	0	0	1	0	0	1	0	0
G. R.*	30	0	0	8	3	0	11	0	0	5	1	0	3	0	0	...	...	...	...	...	...	...	...	...	...	...	...
F. H.*	40	14	0	30	15	4	46	18	9	32	14	0	23	7	1	30	10	10	13	5	0	3	1	0	3	2	0
M. B.	37	5	0	33	17	1	21	8	0	21	8	0	30	9	2	10	4	0	1	0	0	...	...	...	...	...	...
F. W.	24	5	1	16	7	1	22	2	7	1	0	0	2	0	0	...	...	...	...	...	...	...	...	...	...	...	...
A. E.	29	2	1	15	5	1	9	2	2	1	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
M. E.*	34	3	0	45	21	20	16	11	2	3	1	0	12	5	3	11	3	3	3	2	0	0	0	0	2	1	0
P. E.	22	4	0	4	2	0	4	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
H. R.	28	7	0	28	5	0	30	12	4	31	11	3	14	8	0	15	8	1	7	2	0	8	1	0	5	1	0
L. H.	29	4	0	8	5	0	13	4	0	17	3	0	13	2	0	...	...	...	...	...	...	...	...	...	...	...	...
R. S.*	29	7	0	28	10	1	42	21	5	20	7	0	14	5	0	7	2	0	6	2	0	11	3	0	1	0	0
O. E.*	48	27	3	52	17	12	31	14	2	47	28	8	19	9	0	16	6	0	26	10	1	29	16	3	20	4	2
M. C.*	45	20	5	77	44	21	52	17	12	46	23	8	17	6	2	23	7	7	6	0	0	0	0	0	1	0	0
C. N.*	50	19	0	42	25	1	30	14	0	30	16	0	22	13	0	21	12	0	15	6	0	16	8	0	12	9	0
P. N.	29	8	0	48	19	15	14	5	0	12	3	1	3	0	0	1	0	0	...	...	...	...	...	...	...	...	...
Totals	653	176	17	540	242	89	428	146	53	303	119	22	184	70	8	141	58	21	78	27	1	77	37	4	45	17	2
	846			871			627			444			262			220			106			118			64		

TABLE V—*Continued*

Subject	10th			11th			12th			13th			14th			15th			16th			17th			Totals		
	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P	Uc	L	P
A. B.	5	2	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	148	57	11
L. D.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100	31	13
A. R.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	52	21	0
L. E.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	47	3	0
T. R.*	2	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	101	30	8
G. R.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	57	4	0
F. H.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	220	86	24
M. B.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	153	51	3
F. W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	65	14	9
A. E.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	54	9	4
M. E.*	1	1	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	127	48	28
P. E.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30	6	0
H. R.	1	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	166	55	8
L. G.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80	18	0
R. S.*	5	2	0	1	0	0	0	0	0	1	0	0	5	0	1	...	...	...	...	...	...	...	...	...	170	59	7
O. E.*	25	10	2	9	4	0	6	0	0	5	1	0	0	0	0	1	0	0	1	0	0	...	...	...	335	146	33
M. C.*	4	0	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	271	117	56
C. N.*	10	3	0	9	4	0	7	3	0	24	10	5	4	2	0	3	1	0	2	0	0	1	1	0	298	146	6
P. N.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	107	35	16
Totals.	53	18	3	19	8	0	13	3	0	30	11	5	9	2	1	4	1	0	3	0	0	1	1	0	2581	936	226
	74			27			16			46			12			5			3			2			3743		

four persons last described in the preceding sentence are M. B., A. E., F. H., and F. W., respectively. In the table females are marked with an asterisk (*).

Figure I shows in graphic form the average number of errors made in successive repetition series by the nineteen

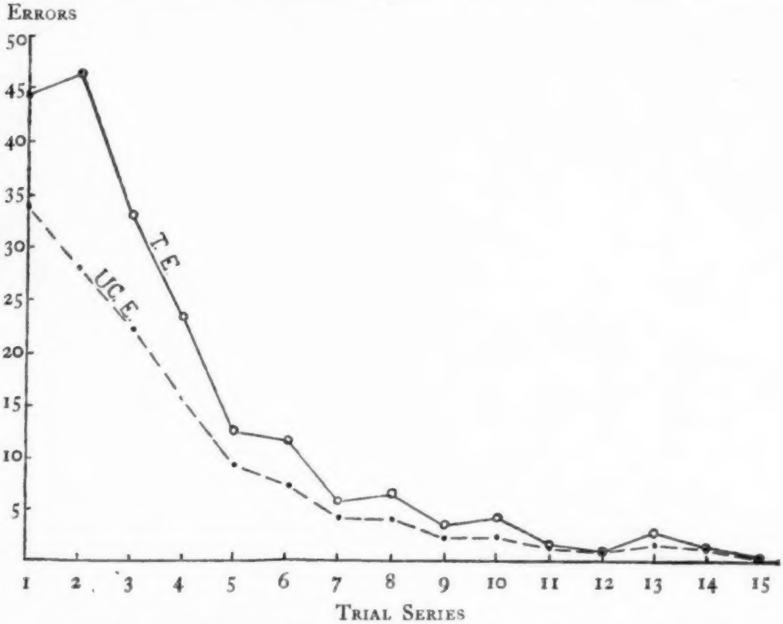

Fig. I. Rational Learning Curve, based on Averages of 19 subjects. UC.E. is the Curve of Unclassified Errors; T.E., that of the Total Errors. Each Trial Series Consists in Guessing Numbers for A, B, C, . . . J.

subjects. UC.E. is the curve of the unclassified errors and T.E. is that of the total errors determined as has been explained. Which of these curves is the more accurately representative of the learning is hard to say without more extended comparisons and analyses. The curve T.E. results from giving greater weight to certain errors than to others. This is true in a measure even of the curve UC.E., for the fewer the logical and the perseverative errors a subject makes the more he is able to limit his field of guess-trials and thus to reduce his errors. These curves in themselves are not very illuminating as they conceal the points of greatest significance in

the learning. The same thing is true to a large extent of the individual curves, which the interested reader may plot for himself from the results as given in Table V.

In this case the error curves should not be regarded as comparable to most error curves of learning without certain qualifications. It has been shown in another article that if the thing to be accomplished successively in different trials be regarded as a constant, K, we have an equation of the form $K = ae$, or $K/a = e$, wherein e represents the errors and a the average attainment of some sort, depending on the nature of the experiment; and that when K is large the e-curve drops relatively very rapidly at first, for purely mathematical reasons, while it shows a more gradual decline when K is small.[1] In our present case K is very small ($= 10$) and we should therefore expect a slow decline of the error curve.

Among the features in which this learning differs from the maze learning, for instance, is this one in particular: when the individual turns back in the maze before reaching the food box or the exit he lays himself liable to certain additional possibilities of error (of entrance to blind alleys already passed) which are avoided as soon as he learns to keep the forward direction. Thus when the subject learns to keep the forward direction, which even the rat in the maze does considerably before it learns to avoid entering blind alleys,[2] he suddenly decreases his number of errors by eliminating at once all those that would have been made had he returned in the maze and been again obliged to pass the blind alleys already passed to the point in question. This is one of the causes of the sudden drop in the error (and time, and excess distance) curve in maze learning, which cause is absent in the present case of rational learning.

It is, however, significant that in this case of rational learning only so few subjects master rather suddenly and noticeably the rational aspects of the situation; thus only a few show a rather significant drop in the error curve or in the total number of errors. The better subjects, and some of

[1] Jos. Peterson, 'Experiments in Ball-Tossing: The Significance of Learning Curves,' J. Exp. Psychol., 1917, 2, 178–224.

[2] See *Behav. Monog.* No. 15, 1917, 24 f., by the writer.

those finding greater difficulty with the problem, show such a drop; but, simple as the problem is, one is not at all safe in concluding from the absence of such a drop that ideas and a degree of rationalization were not employed. It is the particular choices and the numbers avoided by the subject, as shown in his detailed record, that indicate most clearly the degree of reason employed and its exact nature. This fact indicates very strongly that any hasty or general conclusion arrived at from the curves or from general averages, as is too frequently done in studies of learning, is in a high degree unreliable; to understand learning better, as the writer has urged in some of the previous articles already cited, we must take the pains to study its detailed phases. A subject may try one idea and drop it for another; and our present experiment indicates that when the individual reactions are considered, we find many different but rather effective methods used. Yerkes found "that *where very different methods of learning appear, the number of trials is not a safe criterion of intelligence.*"[1] In general, of course, the number of trials and the number of errors do indicate in the present study the degree of rationalization of the reactions; but the kind of error is far more significant.

The writer feels, much more than this rather general report indicates, that the present type of experiment suggests to the person applying it to a subject a number of very significant aspects of the subject's type of mind, traits that are of considerable importance in the selection of individuals for different kinds of work. Individuals of about the same amount of mental ability, as measured by intelligence tests, seem to differ very significantly in some of these traits. And it seems to the writer that by the addition of better controls, such as the use of a means of recording the exact time-relations of the several responses, a very good objective record can be obtained of most of these significant traits. Even by the present method—and it has been the purpose to reduce the technique to as simple a matter as possible—most of these traits show in the individual records.

[1] *Behav. Monog.* No. 12, 1917, p. 68.

Some of the subjects show a cold deliberateness that is not easily disturbed. For them the problem is an intellectual situation to be solved, and they keep cool and considerate of the various factors involved in attempting the solution. There is less evidence of great interest in one's own *personal* record, of the desire to "show up well"; the interest is in finding what people in general will do with the problem. This is the more objective, rational type. Miss G. R. is one of the best examples of this type.

Then there are the individuals of a more subjective turn of mind, who easily get confused and allow their attention to be narrowed down, by emotional disturbances and fear of making a bad record, to irrelevant self-thoughts. The result is that the real situation before the subject is neglected in some of its essential aspects, and we get the inconsistent guessing of numbers which the subject knows perfectly well have been used for other letters but he "didn't think about it." Persons of this kind are rather nervous and uneasy in the test and seem over-concerned about any particular error and keep it in mind to the detriment of subsequent guesses. Any tendency to dwell too much on the past at the expense of the present demands on one's attention is something of a dissociation, and borders on the abnormal. It may, of course, manifest itself in any normal person under peculiar conditions, but some are much more prone to it than are others. It is reasonable to suppose, and abnormal psychology gives many evidences of the correctness of the supposition, that such persons cannot stand the strain that those of the first type can. M. E., H. R., R. S., O. E., and C. N. are of this type. Such persons are considerably concerned about the attitude of others toward them and they probably need more personal motives and attention to do their best work, if this is not carried to the point of confusion.

A third type of individual, best represented by a member of another group of persons tested, strikes out boldly by an almost pure trial and error procedure. The person referred to, a man devoting part of his time to business in the city and part to university work, proceeded at once to guess rapidly

for each letter, seemingly little concerned about errors. It took him an abnormally long time to complete the learning and he made a large number of errors, with a high proportion of logical but a small proportion of perseverative errors; but this did not greatly disturb him as it would have done those of the second type already considered. When he got through I asked: "Are you not a sort of hit-or-miss type of individual in your work and methods of thinking?" He thought a little, and replied that that is a rather good characterization of him. A time record of one's responses would show up this trait better than the records we have show it. The average rate of response can, of course, be derived by dividing the total time by the total number of responses.

Another general classification of certain extreme individuals would put them into classes of aggressive, vigorous attack on the problem, on the one hand, and of so much passivity on the other hand that principles can hardly be discovered. This is a different sort of classification from the one above; the active person, *e. g.*, might be either logical and efficient at the test or self-conscious and confused. One individual, M. C., went through the problem very passively and unconcerned, and had considerable difficulty in mastering it. When finally she succeeded I asked her if she saw any room or opportunity for reasoning the matter out and of thus aiding memory. The reply was: "I don't know that I do." This same sort of passivity characterizes her work in psychology, though she can do nearly average work with the necessary effort.

So much for our venture in 'character reading.' It, of course, remains to be demonstrated that different individuals would characterize these persons, respectively, in the same way, with a fair degree of reliability. Possibly, also, other lines of cleavage are more natural than those suggested. Hamilton found, somewhat in conformity with the present results, that 'excitability' and 'distractability' tended to dispose animals to his reaction types D and E. Type D is defined as "Response by entering a given alley more than once during a given trial, with an interval of effort to escape by

another alley between entrance and reëntrance of the same alley." In type E the animal showed either two or more efforts to escape by some alley or group of alleys during a given trial without intervals of effort to escape by other alleys, or a persistent avoidance of one alley while trying others six or more times.[1]

Rankings on the basis of fewness of errors in this test show with the few subjects here employed a correlation of .86 with the estimated intelligence of the subjects, and of .96 with rankings based on six technical examinations in the general psychology course. The latter correlation is, however, based on only seven cases. Correlations based on a large number of cases will be given in a subsequent article. The present indication is that the rational learning experiment is a rather good test for intelligence, though it obviously has other important uses.

Summary

1. A simple experiment without complex apparatus is devised which enables the experimenter to record objectively with a high degree of accuracy all the relevant reactions of the subject solving the problem in rational learning.

2. The difficulty of the problem can be increased or decreased to any desirable degree, without interfering with the general principle of the experiment. The problem can therefore easily be adapted to human subjects of various intellectual capacities.

3. In a problem in rational learning of this kind it seems to be unsafe to lay down any particular method as the best method of procedure. Some of the best subjects depart from our 'best method' and solve the problem in least time and with fewest errors. With greater complexity in the problem, however, easily provided for in the present learning test, it is probable that the orderly procedure suggested as the best method would show superiority over other procedures.

4. Curves of error in rational learning, when the situation is not too simple, do not show important differences from

[1] G. V. Hamilton, 'A Study of Perseverance Reactions in Primates and Rodents,' *Behav. Monog.* No. 13, 1917, 44 f.

other error curves of learning. The absence of sudden drops in the curve does not prove that the subject did not have, or did not use, ideas; a better criterion of the use of ideas is the consistency of the individual choices of any particular subject.

5. The present rational learning test seems to promise something in the way of an analysis of different individual traits, more or less independent of what is ordinarily regarded as intellectual ability,—such as (1) cold rationalistic tendencies, (2) extreme self-consciousness and a disposition to confusing, emotional excitement, (3) a tendency to a rough trial-and-error procedure with little concern as to errors made, a sort of hit-or-miss type of mind motivated by an abundance of energy poorly directed; and also other classifications of subjects, not coördinate with these, into aggressive alertness in attack on problems, on the one hand, and on the other an extreme passivity, one that does not permit of selection to any adequate extent and that tends too much toward mere contiguity associations not fruitful in the learning.

6. With the few subjects used a very high correlation is obtained between performance in the rational learning and estimated general intelligence or standing in general psychology based on technical examinations.

7. On occasions of mental confusion there is a surprising neglect of certain pertinent elements in the situation reacted to, sometimes called a narrowing of consciousness. Often with very little confusion noted, subjects report that they 'didn't think' of facts which they had learned and had recently used.

8. Rational learning does not seem to differ from the usual trial and error learning in any important manner except in the explicitness with which the various elements in the situation are reacted to and retained for subsequent use. It is probable that in all forms of learning, even in those forms showing no errors, as errors are usually conceived, there is a struggle between various impulsive tendencies and that, by means of overlapping neuro-muscular excitations, inhibitions and facilitations occur which serve as selective agencies and

determine, with other circumstances, the connections formed in the learning. Thus an anticipatory adjustment is possible even though there are no anticipatory ideas or conscious purposes, and the acts most consistent with the total conditions, extra-organic and intra-organic, survive in the learning over those which are more or less conflicting. Empirical justifications of the statements in this paragraph will be given in a later report.

A CONTRIBUTION TO THE EXPERIMENTAL STUDY OF ANALOGY

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Introduction

The researches of Thumb and Marbe[1] on the psychological basis of analogy[2] in language were an attempt to determine what characteristics a word-association must possess in order to become linguistically effective. Their investigation established the following characteristics:

1. The effectiveness of an association in producing analogical changes increases with its *frequency*, *i. e.*, with the number of members of a speech-community in whom it is present. This may be represented algebraically by $E = F/n$ when E represents the effectiveness in producing analogical changes, F the frequency or number of occurrences of the association and n the number of persons under investigation.

2. The effectiveness of an association increases with a decrease in the average *time* required for the association to take place. This may be represented algebraically by $E = 1/(T + 1)$ when T represents the average association-time; with a decrease in the association-time the value of E approaches 1.[3]

Strictly speaking the results of Thumb and Marbe's in-

[1] A. Thumb und K. Marbe, 'Experimentelle Untersuchungen über die psychologischen Grundlagen der sprachlichen Analogiebildung,' Leipzig, Engelmann, 1901.

[2] By 'analogy' and 'analogical changes' we mean those changes in the form or meaning of words or groups of words which are brought about through association with other words or groups of words.

[3] In a further investigation, published in *Indogermanische Forschungen*, **22**, 1–55, Thumb established an additional characteristic for linguistically effective associations, namely their 'spontaneous' nature. In this type of association the associated word follows immediately after the stimulus-word without any intervening mental process. In my experiments the association-types were not investigated, for reasons set forth below.

vestigation are applicable only to the German Language; or still more strictly only to the dialect of his observers.

The Problem.—Briefly stated my problem was (1) to make a beginning in the establishing of the associational basis of the English language and (2) to make a comparative study of the English and German results.

Experimental Investigation

In the first experiments of Thumb and Marbe, a list of 60 words was chosen from different categories as follows: 10 names expressive of family relations, *e. g.*, father, mother, etc., 10 adjectives, 10 numerals from 1 to 10, 10 pronouns, 10 adverbs of place, 10 adverbs of time. All sixty of these words were presented to each observer at one sitting. They were arranged in such an order than in no case would a word immediately follow another of the same category; miscellaneous words not belonging to the list selected for the experiment were frequently interposed. The observers were eight in number, all students, teachers, or doctors of philosophy. In a later experiment 80 verbs (infinitives) were used as stimulus words. Eight observers were again used, three of whom (students) had not served in the first experiment. A stop-watch was used to measure the reaction-time in the first experiment and a Hipp chronoscope and voice key in the later investigation. The results of the two investigations do not differ materially from each other. In very few cases do the favored associations of the one investigation differ from those of the other.

In my experiments, conducted in the psychological laboratory of the Ohio State University in the spring and summer of 1917, 126 observers were used. These fall into three groups. The members of Group A (100 students) are classified in the following table according to their standing as represented in the table. The four vertical columns, numbered 1, 2, 3, 4, refer to the four undergraduate classes; the remaining columns, designated by Roman numerals, refer to the following classes: I, graduate students; II, professors; III, a group of high school teachers who attended the Uni-

versity Summer School of 1917; IV, a group of elementary school teachers who attended the same summer school.

	1	2	3	4	I	II	III	IV	Total
Men..........	14	3	5	3	5	2	21	2	55
Women.......	6	10	6	3	3		9	8	45

Group B consisted of 11 children, aged 9 to 13 years. Group C consisted of 15 university janitors. By means of Group A, I desired to test out the results of Thumb and Marbe with a large group of observers, as compared with the very small group used by the German investigators. This large group was supplemented by the other two groups in order that the results gained from educated adults might be compared with those from uneducated adults and children.

The stimulus-words used were made to correspond as nearly as possible to those used by Thumb and Marbe in their earlier experiments. They fall into six categories, as follows: 10 names of personal relations, 10 adjectives, 10 numerals (1 to 10), 10 verbs (present participles), 10 pronouns, 10 adverbs of time and place. The participles of verbs were used to prevent verbs such as *walk*, used in the infinitive, from being understood as nouns. Only one- and two-syllable words were used, to avoid the possibility of the reaction time being increased by the length of the stimulus-word. Hence no translation of German *Schwager*, etc., was used. A preliminary experiment had been undertaken to discover whether there were any marked difference in length between the reaction-times when one-syllable stimulus words were used and when two-syllable words were used. The results showed the time for the two-syllable words practically the same as for the one-syllable words; the difference may therefore be regarded as negligible for our purposes.

The method employed was as follows: a Hipp chronoscope was set up in a room adjoining that in which the observer and experimenter sat. This was to prevent the sound of the chronoscope from disturbing the observer. The experimenter controlled the chronoscope by means of a key

which was connected by wiring with the instrument. The chronoscope readings were taken by an assistant.[1]

The following instructions were read to each observer:

Please keep your eyes closed during the experiment. I will read you a list of words. To each word respond as quickly as possible with another word. The first five words will be for practice.

I then gave the following words: *house*, *jumping*, *fast*, *red*, *who*. The words chosen for the experiment then followed. These were arranged in ten different haphazard orders, so that in each ten observers no one was given the stimulus-words in the same order. As the experimenter began the articulation of each word, he pressed the key which started the chronoscope; when the observer began to respond the experimenter released the key, thus stopping the chronoscope. (The experimenter did not look at the observer during the experiment, but released the key upon receiving the auditory stimulus of the observer's response.)

No attempt was made to classify the associations according to the occurrence or non-occurrence of mental processes intervening between the stimulus and reaction words, because this would have required introspection on the part of the observers, whereas it was my desire to make the conditions of the experiment as simple as possible, thus approaching more nearly the conditions in everyday speech. Moreover, as Thumb himself notes,[2] the 'spontaneous' character of an association may be inferred from the rapidity with which it occurs; the associations having the shortest reaction-times are the 'spontaneous' ones.

In the following tables, the results for Group A are presented. The figures in parentheses, placed after the stimulus-words, indicate the total number of successful reactions. The columns under n, A and M give the number of occurrences, the average reaction-time and the median[3] of the re-

[1] Miss Ethel M. Cooke, a student in the university, to whom I am greatly indebted for her careful and patient work.

[2] *Indogerman. Forsch.*, 22, 18, 24.

[3] The median is to be regarded as more significant than the average because it is not affected by the extremely long or short reaction-times. We are concerned, not so much with the *average* times as with the *most frequent* times.

TABLE I

Stimulus	Most Frequent Reaction				Next Most Frequent Reaction				All Remaining Reactions		
		n	A	M		n	A	M	n	A	M
1. *father........(95)	*mother.......	69	1.265	1.160	son...........	4	1.266	1.248	22	2.229	1.904
2. *mother.......(96)	*father........	55	1.310	1.219	sister..........	7	1.300	1.289	34	2.321	1.976
3. *son[1].........(44)	daughter......	27	1.443	1.223	father.........	7	2.129	2.124	10	2.155	2.044
4. *daughter.....(94)	son..........	35	1.603	1.347	sister	15	1.404	1.212	44	2.181	1.765
5. *brother......(94)	*sister.........	72	1.165	1.060	relative[2]	3	2.087	1.437	19	2.479	2.313
6. *sister........(98)	*brother.......	72	1.208	1.146	girl...........	4	2.364	2.214	22	1.989	1.908
7. cousin.......(97)	uncle.........	20	1.623	1.314	aunt..........	19	2.308	1.843	58	2.038	1.960
8. aunt ....(89)	uncle.........	67	1.327	1.290	Mary.........	4	2.038	1.700	18	2.060	1.894
9. uncle........(99)	aunt.........	66	1.335	1.228	relative[3].......	4	1.648	1.596	29	2.021	1.870
10. nephew......(96)	niece.........	58	1.600	1.472	cousin.........	10	1.680	1.698	27	2.330	1.931
1. Vater..........(8)	Mutter.......	5	1.24		——	-	—		3	2.13	
2. Mutter...........	Vater........	3	1.67		meine M.......	2	3.00		3	1.93	
3. Sohn.............	Vater........	5	1.36		Tochter.......	2	2.10		1	3.80	
4. Tochter..........	Mutter.......	4	1.50		——	-	—		4	1.70	
5. Bruder...........	Schwester.....	6	1.33		——	-	—		2	4.30	
6. Schwester........	Bruder.......	4	1.90		——	-	—		4	1.60	
7. Vetter...........	Base.........	3	1.40		Schwester......	2	1.60		3	2.67	
8. Base.............	Vetter........	5	1.88		——	-	—		3	3.27	
9. Schwager.........	Bruder.......	2	1.60		——	-	—		6	2.70	
10. Schwägerin.......	——	-	—		——	-	—		8	2.25	

[1] The small number of successful reactions to the stimulus 'son' is due to the fact that many observers understood it as 'sun.'

[2] Including 1 case of 'relation.'

[3] Including 2 cases of 'relation.'

TABLE II

Stimulus	Most Frequent Reaction				Next Most Frequent Reaction				All Remaining Reactions		
		n	A	M		n	A	M	n	A	M
1. *big..........(93)	*little.........	52	1.150	1.079	small........	18	1.208	1.132	23	1.922	1.599
2. *little.........(93)	*big...........	52	1.280	1.224	small........	17	1.458	1.309	24	2.073	1.811
3. *light[1]											
4. *heavy........(96)	*light..........	73	1.356	1.272	load.........	6	1.450	1.455	17	2.479	1.839
5. *old..........(93)	*young........	69	1.382	1.223	new..........	7	1.105	1.124	17	2.200	2.201
6. *young........(97)	*old...........	80	1.179	1.102	man..........	4	1.348	1.301	13	2.872	2.186
7. *thick........(99)	*thin..........	72	1.346	1.214	heavy.......	4	1.538	1.589	23	2.620	2.030
8. *thin.........(93)	*thick.........	50	1.351	1.217	fat...........	17	1.499	1.427	26	2.089	1.688
9. *white........(96)	*black.........	74	1.181	1.128	dark.........	3	1.216	1.078	16	1.969	1.694
					light.........	3	1.632	1.772			
10. *black.........(98)	*white.........	79	1.173	1.097	color........	3	2.314	1.693	16	2.059	2.054
1. gross.........(8)	klein.........	7	1.29						1	2.40	
2. klein.............	gross.........	6	1.37						2	2.00	
3. leicht............	schwer.......	7	1.46						1	2.00	
4. schwer...........	leicht........	6	1.23						2	1.90	
5. alt...............	jung.........	6	1.30						2	2.40	
6. jung.............	alt...........	7	1.17						1	2.20	
7. dick.............	dünn.........	7	1.26						1	2.00	
8. dünn.............	dick..........	7	1.29						1	2.00	
9. weiss............	schwarz......	7	1.63						1	1.60	
10. schwarz	weiss.........	6	1.43						2	2.50	

[1] Out of a total of 97 observers who responded to the stimulus 'light,' only 4 understood it in the sense intended, *i.e.*, German 'leicht,' 'not heavy.' The results are as follows:

	Most Frequent Reaction	Av. Time	Av. Time of Other Reactions
1. Understood as 'not heavy' (4)	heavy (4)	1.299	——
2. Understood as 'not dark' (58)	dark (54)	1.281	1.802
3. Understood as a noun (35)	darkness (6)	1.251	2.038

TABLE III

Stimulus	Most Frequent Reaction				Next Most Frequent Reaction				All Remaining Reactions		
		n	A	M		n	A	M	n	A	M
1. *one (97)	*two	78	1.160	1.102	—	–	—	—	19	2.316	2.030
2. *two (92)	*three	56	1.250	1.127	four	13	1.440	1.377	23	1.783	1.546
3. *three (98)	*four	68	1.163	1.084	number	9	1.599	1.515	21	1.749	1.515
4. *four[1] (83)	*five	53	1.168	1.096	three six number	5 5 5	1.486 1.304 2.893	1.385 1.308 2.214	15	2.116	2.021
5. *five[1] (87)	*six	55	1.296	1.254	ten	8	1.577	1.398	24	1.817	1.653
6. *six (94)	*seven	65	1.102	1.044	number	5	3.104	2.154	24	1.954	1.828
7. *seven (99)	*eight	68	1.220	1.114	number	6	1.580	1.410	25	2.122	1.747
8. *eight (91)	*nine	66	1.183	1.090	ten	5	1.023	1.179	20	1.814	1.626
9. *nine (97)	*ten	73	1.352	1.186	number	5	1.831	1.544	19	2.198	2.157
10. *ten (97)	eleven	51	1.219	1.131	twenty	8	1.599	1.562	38	1.946	1.549
1. eins (8)	zwei	5	1.20		—	–	—		3	2.13	
2. zwei	drei	4	1.15		—	–	—		4	1.75	
3. drei	vier	5	1.32		—	–	—		3	2.00	
4. vier	fünf	6	1.13		—	–	—		2	2.20	
5. fünf	sechs	6	1.17		—	–	—		2	6.70	
6. sechs	sieben	5	1.16		—	–	—		3	2.00	
7. sieben	acht	6	1.33		—	–	—		2	2.20	
8. acht	neun	6	1.43		—	–	—		2	6.00	
9. neun	zehn	5	1.52		—	–	—		3	1.87	
10. zehn	zwanzig	3	1.60		elf	2	1.20		3	2.33	

[1] The relatively small number of successful reactions to the stimulus words 'four' and 'five' is due to many observers understanding these as 'for' and 'fife' respectively.

TABLE IV

Stimulus	Most Frequent Reaction	n	A	M	Next Most Frequent Reaction	n	A	M	All Remaining Reactions n	A	M
1. *giving.......(98)	*taking........	39	1.396	1.306	{ receiving.....	7	1.473	1.489	45	2.052	1.727
					{ money.......	7	1.925	1.861			
2. *taking.......(93)	*giving........	16	1.626	1.400	receiving.....	8	2.090	1.895	69	2.150	2.009
3. *eating.......(94)	*drinking......	42	1.446	1.332	food.........	11	1.933	1.724	41	2.056	1.642
4. *drinking.....(95)	eating........	30	1.863	1.815	water........	25	1.632	1.453	40	2.069	1.593
5. *losing[1].......(81)	finding.......	29	1.459	1.422	{ gaining......	9	1.368	1.288	34	1.990	1.499
					{ lost.........	9	1.627	1.478			
6. *walking......(97)	*running.......	29	1.547	1.376	riding.......	17	1.486	1.464	51	1.826	1.665
7. *reading......(96)	*writing.......	55	1.298	1.200	book.........	18	2.108	1.810	23	2.358	1.743
8. *writing.......(97)	*reading.......	43	1.729	1.674	letter(s).....	8	1.722	1.692	46	1.831	1.722
9. seeking[1]......(83)	finding.......	28	1.490	1.399	looking[2].....	8	1.712	1.634	47	2.013	1.838
10. *finding.......(92)	losing........	20	1.915	1.699	lost..........	10	1.566	1.574	62	2.174	1.883
1. geben.........(8)	nehmen.......	4	1.75		——	–	—		4	2.30	
2. nehmen..........	geben........	6	1.33		——	–	—		2	1.80	
3. essen............	trinken.......	6	1.13		——	–	—		2	1.90	
4. trinken..........	winken.......	2	1.40		——	–	—		6	1.37	
5. verlieren.........	Geld.........	6	1.90		——	–	—		2	1.90	
6. gehen............	laufen........	2	1.30		——	–	—		6	1.93	
7. lesen.............	schreiben.....	5	1.16		Buch........	2	1.70		1	2.00	
8. schreiben.........	lesen.........	4	1.15		——	–	—		4	3.50	
9. ——[3]											
10. finden...........	suchen.......	4	1.40		——	–	—		4	1.50	

[1] The stimulus words 'losing' and 'seeking' were not used for the first 14 observers; hence the smaller number of responses.

[2] 'hunting' occurs 7 times (A, 1.486 M, 1.416); 'hunt' occurs 3 times (A, 2.192 M, 2.034). Taking these two responses together, the results are: n, 10 A, 1.698 M, 1.568. The association seeking-hunt(ing) thus appears stronger than seeking-looking.

[3] 'suchen' does not occur as a stimulus word in the German investigation. Out of a total of 80 verbs which T&M used as stimulus words, I have taken only those which correspond to those used by me; whereas in the case of the other categories, where T&M use only 10 words, I have given them all.

TABLE V

Stimulus	Most Frequent Reaction	n	A	M	Next Most Frequent Reaction	n	A	M	All Remaining Reactions n	A	M
1. *I[1] (46)	*you	27	1.358	1.265	me	6	1.666	1.653	13	1.678	1.381
2. *you (92)	me	26	1.357	1.274	they	10	1.733	1.519	56	2.009	1.709
3. *we (91)	they	28	1.404	1.403	us	20	1.540	1.414	43	1.794	1.450
4. *he (89)	*she	48	1.273	1.226	man	7	2.264	1.855	34	1.681	1.440
5. her (87)	she	27	1.357	1.267	him	23	1.765	1.558	37	1.935	1.771
6. it (90)	they	20	2.240	1.856	that	9	1.826	1.842	61	2.096	1.938
7. they (94)	them	29	1.743	1.592	we	16	1.608	1.418	49	2.073	1.653
8. *this (95)	*that	68	1.165	1.097	what	3	1.619	1.696	24	2.030	2.106
9. *that (97)	*this	47	1.307	1.211	{ which { what	6 6	1.346 1.998	1.324 1.820	38	2.113	1.904
10. *what (94)	when	20	1.445	1.336	that	14	1.953	1.584	60	2.043	1.724
1. ich (8)	du	4	1.25		er	3	1.53		1	3.00	
2. du	er	5	1.28		—	–	—		3	2.07	
3. wir	{ uns { ihr	3 3	1.47		—	–	—		2	2.30	
4. er	sie	4	1.30		—	–	—		4	2.75	
5. sie	er	3	0.93		—	–	—		5	1.76	
6. ihr	wir	3	1.60		{ sie { seid	2 2	{ 1.60		1	5.00	
7. wer	er	3	1.60		ist	2	3.80		3	2.13	
8. dieser	jener	6	1.33		Mann	2	2.50		–	—	
9. jener	dieser	4	1.30		—	–	—		4	1.75	
10. was	das	4	1.60		—	–	—		4	1.80	

[1] The stimulus word 'I' was understood by many observers as 'eye.'

TABLE VI

Stimulus	Most Frequent Reaction				Next Most Frequent Reaction				All Remaining Reactions		
		n	A	M		n	A	M	n	A	M
1. *where........(98)	when.........	33	1.478	1.339	there..........	23	1.464	1.401	42	1.798	1.626
2. *here[1].........(64)	*there.........	37	1.420	1.159	now...........	10	1.391	1.222	17	1.820	1.935
3. *there[2]........(70)	*here..........	23	1.396	1.256	where.........	20	1.813	1.635	27	2.198	1.978
4. *now.........(94)	then..........	55	1.426	1.330	when..........	10	1.809	1.327	29	1.979	1.824
5. *then[3]........(68)	now..........	34	1.870	1.480	when..........	12	1.916	1.504	22	1.952	1.652
6. *when........(96)	now..........	21	1.737	1.559	where.........	20	1.453	1.333	55	1.776	1.485
7. *never........(89)	now..........	17	1.506	1.368	always........	15	1.649	1.444	57	2.249	1.733
8. *always.......(93)	*never.........	37	1.774	1.489	now...........	20	2.030	1.731	36	2.238	1.976
9. seldom.......(94)	often.........	42	1.815	1.548	never..........	14	1.818	1.768	38	2.261	1.950
10. often........(90)	seldom.......	20	1.573	1.496	soon..........	14	1.620	1.377	56	2.297	1.884
1. wo...........(8)	da...........	4	1.45		——	–	—		4	2.40	
2. hier.............	dort..........	6	1.37		——	–	—		2	2.30	
3. dort.............	hier..........	5	1.32		——	–	—		3	2.47	
4. jetzt............	nie...........	2	7.30		——	–	—		6	1.87	
5. dann.............	wann.........	6	1.70		——	–	—		2	1.90	
6. wann.............	dann.........	5	1.68		wo............	2	1.50		1	8.00	
7. niemals..........	jemals........	5	1.72		——	–	—		3	2.87	
8. immer...........	nimmer.......	2	1.60		——	–	—		6	1.93	
9. ——[4]											
10. ——[4]											

[1] frequently understood as *hear*.

[2] frequently understood as *their*.

[3] frequently misunderstood as *them*.

[4] *selten* and *oft* do not occur as stimulus-words in the German investigation. T&M used 10 adverbs of place and 10 adverbs of time. Of these I have given above only those which correspond to my stimulus-words.

action-times, respectively, of the most frequent response, the next most frequent response and of all remaining responses. A star before a stimulus-word indicates that it occurs as a stimulus word in the experiments of Thumb and Marbe; a star before a most frequent response indicates that it was also the favored response in the German investigation. Below each table is given the corresponding German table.

Of the 60 stimulus-words used in my investigation, 50 correspond to stimulus-words used by Thumb and Marbe. Of the most frequent responses to these 50 words, 35, or 70%, agree with the favored German reactions. It should be noted, moreover, that in some cases where the favored English response is not the same as the favored German response, the next most frequent response of the one investigation agrees with the most frequent of the other. Thus the responses to *son* (*Sohn*) are *daughter* (*Vater*); *Tochter* however occurs as the next most frequent German response and *father* as the next most frequent English response. It is quite possible that had Thumb and Marbe used a larger group of observers, the agreement between the German and English results would have been still greater.

In both the English and German experiments, stimulus-words of a given category were responded to predominantly with words of the same category, as the following figures show. (German percentages are given in parentheses.)

1. Names of personal relations responded to names of presonal relations: 77.4% (80%).

2. *Adjective responses to adjectives:* 85.3% (87.5%).

3. *Numeral responses to numerals:* 83.9% (87.5%).

4. *Pronoun responses to pronouns:* 72.9% (71.3%).

5. *Adverbs of place responded to adverbs of place:* 51.7% (68.8%).

Adverbs of time responded to adverbs of place: 26.3% (1.2%).

6. *Adverbs of time responded to adverbs of time:* 72.4% (76.3%).

Adverbs of place responded to adverbs of time: 6.9% (6.2%).

7. *Verb responses to verbs:* 70.2% (42.0%).
Noun responses to verbs: 23.3% (51.7%).

The English and German results are seen to agree closely in this respect except in the case of the responses to adverbs of place and to verbs. The English observers show a marked tendency to respond to adverbs of place with adverbs of time, whereas in the case of the German observers this tendency is hardly present. A decided difference is seen between the English and German responses to verbs. The results for the English observers are here similar to the results in the other categories, whereas only 42.0% of the German responses to verbs are again verbs. To what this difference is due may be inferred from a comparison of the results of Schmidt.[1] In this investigation, 8 boys, aged about 10 years, acted as observers. The stimulus-words were the forms of the present and imperfect indicative, the present infinitive and the past participle of 30 verbs. Of the responses to these words, 89.65% were verbs, 4.82% substantives and 5.53% scattering. Although Schmidt does not himself give us the necessary data, we may infer from a comparison of the results of Thumb and Marbe that most of the substantive and scattering responses were given as reactions to the 30 infinitives. "Das Resultat ist sprachpsychologisch nicht uninteressant; wir betrachten den Infinitiv als Träger der Verbalbedeutung, als die abstrakte Verbalform, und können daher a priori verstehen dass der Infinitiv mit sonstigen Wortklassen durch die Wortbedeutung assoziativ enger verknüpft ist als eine finitive Verbalform, deren assoziative Beziehungen mehr durch die formale Seite bestimmt sind."[2] Since the English observers were given participles as stimulus-words and the German observers infinitives, the difference in the results is probably due to the difference in the stimulus-words. If this is so, we see between the infinitive and finite forms, besides the linguistic difference, also a decided psychological difference.

It is to be noted also that of the responses to adjectives,

[1] *Ztschr. f. Pscyhol. u. Physiol. d. Sinnesorgane*, **28**, p. 65 ff.

[2] Thumb, *Indoger. Forsch.*, **22**, 35.

76.5% were adjectives of meanings *opposed* to those of the stimulus-words. For the German responses the percentage was 82.5%. In the case of the numerals, the most frequent response to each stimulus-word was the *next higher numerals* in the German results the response *zwanzig* to the stimulus *zehn* offers an apparent exception to this rule;[1] the next most frequent response is however *elf*.

There are 17 cases of reciprocal associations, as follows: father ⇄ mother, son ⇄ daughter, brother ⇄ sister, uncle ⇄ aunt, big ⇄ little, light ⇄ heavy, old ⇄ young, thick ⇄ thin, white ⇄ black, giving ⇄ taking, eating ⇄ drinking, losing ⇄ finding, reading ⇄ writing, this ⇄ that, here ⇄ there, now ⇄ then, seldom ⇄ often.

It remains for us to consider the relations between the reaction-times for the most frequent, next most frequent and remaining responses. Thumb and Marbe found in their experiments that the more frequent a response was, the shorter was its reaction time. The following table will show that the same rule applies to the English results. In the lines marked *a*, *b* and *c* are given the average reaction-times of the most frequent, next most frequent and remaining responses, respectively, to the stimulus-words of each of the six categories. At the right are given the medians of all six categories.

	Family Names	Adjectives	Numerals	Verbs	Pronouns	Adverbs	Total
(*a*)	1.387	1.258	1.211	1.577	1.465	1.600	1.416
(*b*)	1.822	1.477	1.767	1.720	1.756	1.696	1.706
(*c*)	2.180	2.254	1.982	2.052	1.945	2.057	2.078

Results of Groups B and C

In the following tables are given the results for Group B (children) and Group C (uneducated adults). The figures in parentheses after the stimulus-words indicate the total number of successful reactions; the columns under *n* and *M* give the number of occurrences and median time of the most

[1] I say 'apparent' because in the very common 'counting by tens' *twenty* may be regarded as the next higher numeral after *ten*. The English table also shows the influence of counting by twos and by fives.

Group B

	Stimulus	Most Frequent Reaction			Next Most Frequent Reaction			All Remaining Reactions	
			n	M		n	M	n	M
Table Ib...	1. father....(10)	*mother....	10	1.439	——	–	——	–	——
	2. mother...(11)	*father.....	10	1.456	son....	1	1.924	–	——
	3. son.......(6)	*daughter...	4	1.417	——	–	——	2	1.834
	4. daughter..(11)	*son........	9	1.921	——	–	——	2	1.556
	5. brother...(11)	*sister......	11	1.330	——	–	——	–	——
	6. sister.....(11)	*brother....	9	1.412	——	–	——	2	1.310
	7. cousin....(11)	*uncle......	3	1.485	niece...	2	1.928	1	1.590
		sister......	3	2.087	aunt...	2	4.734	–	——
	8. aunt.....(11)	*uncle......	9	1.707	——	–	——	2	3.338
	9. uncle.....(10)	*aunt.......	5	1.553	cousin..	3	1.559	2	2.120
	10. nephew...(11)	*niece......	7	1.593	cousin..	2	2.082	2	2.522
Table IIb..	1. big.......(11)	*little......	10	1.422	——	–	——	1	1.286
	2. little.....(11)	*big........	10	1.460	——	–	——	1	2.333
	3. light[1]								
	4. heavy....(11)	*light.......	8	1.654	——	–	——	3	1.774
	5. old.......(11)	*young.....	11	1.447	——	–	——	–	——
	6. young....(11)	*old........	11	1.398	——	–	——	–	——
	7. thick.....(10)	*thin.......	6	1.924	——	–	——	4	2.291
	8. thin.......(9)	*thick......	4	1.550	——	–	——	1	1.653
		fat........	4	2.518					
	9. white....(11)	*black......	9	1.164	blue....	2	2.012	–	——
	10. black.....(11)	*white......	9	1.296	——	–	——	2	1.714
Table IIIb..	1. one.......(9)	*two.......	8	1.437	——	–	——	1	1.586
	2. two......(11)	*three......	4	1.285	——	–	——	3	1.645
		four.......	4	1.986					
	3. three.....(11)	*four.......	8	1.397	——	–	——	3	1.893
	4. four.......(9)	*five.......	3	1.298	three...	2	1.890	4	3.542
	5. five.......(7)	*six........	4	1.433	——	–	——	3	1.333
	6. six.......(11)	*seven......	7	1.266	twelve..	2	3.586	2	1.417
	7. seven....(11)	*eight......	4	1.261	six.....	3	1.469	4	1.716
	8. eight......(8)	*nine.......	3	1.403	ten.....	2	2.745	3	2.286
	9. nine......(10)	*ten........	8	1.604	——	–	——	2	1.426
	10. ten.......(10)	*eleven.....	4	1.549	——	–	——	6	1.790
Table IVb..	1. giving....(10)	gave......	2	1.314	——	–	——	6	2.375
		keeping....	2	2.145					
	2. taking.....(9)	keeping....	2	3.308	——	–	——	7	2.321
	3. eating....(10)	*drinking...	3	1.971	ate.....	2	1.424	5	2.097
	4. drinking..(11)	*eating.....	3	2.221	drank..	2	1.644	4	4.072
					cup....	2	1.914		
	5. losing....(11)	*finding....	4	2.654	found...	3	2.227	4	1.522
	6. walking....(9)	*running....	3	2.241	slow....	2	2.838	4	1.789
	7. reading...(10)	*writing....	5	1.427	read....	2	1.204	3	3.053
	8. writing...(11)	*reading....	3	1.749	wrote...	2	1.428	4	3.366
					playing.	2	6.942		
	9. seeking....(9)	——	—	——	——	–	——	9	2.196
	10. finding...(10)	*losing.....	4	2.284	keeping	2	5.590	4	1.742

[1] Understood only once as 'not heavy'; response *heavy*, time 1.679. Understood 10 times as 'not dark'; response *dark* occurs 8 times, median time 1.365; time of other two responses 1.588.

Group B—*Continued*

	Stimulus	Most Frequent Reaction			Next Most Frequent Reaction			All Remaining Reactions	
			n	M		n	M	n	M
Table Vb...	1. I.........(6)	*you.......	3	1.532	——	–	——	3	2.249
	2. you......(10)	*me........	4	1.350	——	–	——	6	2.418
	3. we........(9)	*they.......	2	1.469	——	–	——	5	2.834
		you.......	2	2.169		–			
	4. he.......(10)	*she........	7	1.555	her.....	2	1.449	1	.953
	5. her......(11)	him.......	4	1.841	he.....	2	2.046	3	2.097
					his.....	2	1.547		
	6. it.........(8)	is.........	2	3.298	——	–	——	6	1.876
	7. they.....(10)	*them......	4	2.179	——	–	——	6	1.942
	8. this......(11)	*that.......	7	1.267	——	–	——	4	2.300
	9. that......(11)	*this.......	4	2.002	there...	2	2.238	5	1.894
	10. what......(9)	who.......	2	1.514	——	–	——	5	2.446
		that.......	2	2.097					
Table VIb..	1. where....(11)	there......	6	1.538	when ..	2	1.876	3	3.237
	2. here.......(8)	*there......	5	1.851	where..	2	1.590	1	2.088
	3. there.....(10)	*here.......	4	1.618	then....	2	1.550	4	3.758
	4. now......(11)	*then.......	7	1.607	——	–	——	4	2.212
	5. then......(8)	*now.......	4	1.646	——	–	——	4	1.752
	6. when.....(10)	*now.......	4	1.935	——	–	——	6	1.836
	7. never....(10)	*now.......	2	2.047	——	–	——	6	2.388
		always.....	2	2.928					
	8. always....(10)	*never......	4	2.024	now....	2	1.568	4	2.322
	9. seldom....(7)	*often......	5	2.267	——	–	——	2	4.738
	10. often.....(10)	slow.......	2	2.814	——	–	——	6	7.378
		soon.......	2	3.464					

Group C

	Stimulus	Most Frequent Reaction	n	M	Next Most Frequent Reaction	n	M	All Remaining n	All Remaining M
Table Ic....	1. father....(15)	*mother....	10	1.463	——	–	——	5	4.525
	2. mother...(15)	*father.....	8	1.916	sister...	3	1.967	4	2.040
	3. son.......(5)	*daughter...	3	2.873	——	–	——	2	2.232
	4. daughter..(15)	brother....	5	2.749	father..	3	1.726	7	1.814
	5. brother...(15)	*sister......	8	1.424	——	–	——	7	2.390
	6. sister.....(15)	*brother....	11	1.669	——	–	——	4	1.982
	7. cousin....(15)	*uncle......	5	2.848	aunt...	4	1.653	6	2.516
	8. aunt.....(13)	*uncle......	6	1.482	no.....	2	1.758	5	1.748
	9. uncle.....(14)	*aunt......	4	2.132	sister...	2	1.298	4	2.278
		cousin.....	4	2.624	——				
	10. nephew...(14)	*niece......	4	1.952	——	–	——	6	1.923
		uncle......	4	2.156					
Table IIc ..	1. big ......(12)	*little	5	1.847	small ..	3	1.467	4	1.814
	2. little.....(14)	large......	6	2.285	big.....	3	1.651	5	1.501
	3. light[1]								
	4. heavy....(15)	*light......	8	1.675	load....	2	1.942	5	2.063
	5. old.......(14)	*young.....	10	1.386	——	–	——	4	2.277
	6. young....(14)	*old........	12	1.492	——	–	——	2	1.279
	7. thick.....(14)	*thin.......	10	2.170	——	–	——	4	1.496
	8. thin......(12)	*thick......	7	1.405	——	–	——	5	3.415
	9. white....(15)	*black......	8	1.780	red.....	2	1.775	3	2.504
					blue....	2	2.966		
	10. black.....(14)	*white......	7	1.534	yellow..	2	1.987	5	1.721

[1] Understood 3 times as 'not heavy'; responses and reaction-times as follows: *heavy*, 2.719; food, 2.524; clothes, 3.704. Understood 4 times as 'not dark'; response *dark*, median time 1.468. Understood as noun 8 times; response *darkness* occurs twice, time 1.808; median time of other responses 1.598.

GROUP C—*Continued*

	Stimulus	Most Frequent Reaction	n	M	Next Most Frequent Reaction	n	M	All Remaining Reactions n	All Remaining Reactions M
Table IIIc..	1. one......(15)	*two.......	8	1.506	four....	2	1.842	5	1.818
	2. two......(15)	*three......	5	1.116	——	–	——	5	2.115
		four.......	5	1.828					
	3. three.....(15)	*four.......	7	1.374	five....	2	2.134	4	3.104
					six.....	2	1.767		
	4. four.......(9)	six........	4	2.256	——	–	——	5	2.464
	5. five......(12)	*six........	5	1.932	eight...	2	2.790	5	1.957
	6. six.......(15)	*seven......	4	1.352	ten.....	3	2.175	8	1.985
	7. seven....(15)	*eight......	10	1.688	——	–	——	5	1.398
	8. eight.....(13)	*nine.......	3	1.536	ten.....	2	1.268	8	2.410
	9. nine......(15)	*ten........	5	1.459	——	–	——	10	1.994
	10. ten......(15)	*eleven.....	4	1.427	nine....	2	1.226	7	2.553
					twelve..	2	2.955		
Table IVc..	1. giving....(15)	*taking.....	6	1.394	——	–	——	9	1.990
	2. taking....(14)	something..	3	1.934	giving..	2	2.362	9	1.563
	3. eating....(15)	*drinking...	8	2.065	——	–	——	7	1.863
	4. drinking..(14)	*eating.....	2	2.164	——	–	——	10	2.160
		whiskey...	2	2.591					
	5. losing....(15)	*finding....	4	1.652	found...	3	2.040	5	1.634
					lost....	3	1.876		
	6. walking...(14)	*running....	5	1.421	talking.	3	1.457	6	1.845
	7. reading...(15)	*writing....	5	1.432	——	–	——	5	2.222
		spelling....	5	2.400					
	8. writing...(14)	*reading....	5	1.627	spelling.	3	1.800	6	2.639
	9. seeking...(15)	*finding....	3	1.770	——	–	——	9	1.729
		looking....	3	3.046					
	10. finding...(15)	lost.......	4	1.478	losing...	3	1.840	8	1.672
Table Vc...	1. I.........(8)	*you.......	2	2.265	——	–	——	6	1.567
	2. you......(14)	*me........	4	1.692	——	–	——	10	2.340
	3. we.......(14)	those......	2	1.438	——	–	——	10	1.589
		she........	2	1.567					
	4. he.......(13)	*she........	6	1.238	——	–	——	7	1.689
	5. her......(10)	*she........	4	1.372	him....	2	2.890	4	2.934
	6. it........(15)	that.......	2	1.662	——	–	——	11	2.421
		now.......	2	2.821					
	7. they.....(13)	*them......	3	2.180	——	–	——	10	1.553
	8. this......(14)	*that.......	8	1.750	——	–	——	6	2.457
	9. that......(15)	*this.......	4	1.450	they....	2	1.196	9	2.296
	10. what.....(15)	now.......	2	2.325	——	–	——	9	1.555
		who.......	2	4.922					
		is.........	2	2.044					
Table VIc..	1. where....(15)	there......	4	1.494	here....	3	3.264	8	1.762
	2. here.......(7)	*there......	3	1.656	——	–	——	4	1.796
	3. there.....(12)	*here.......	3	2.342	where..	2	2.664	7	2.075
	4. now......(13)	*then.......	8	1.701	——	–	——	5	2.102
	5. then.....(11)	*now.......	3	1.745	——	–	——	8	2.243
	6. when.....(13)	*now.......	5	2.071	where..	2	3.847	4	1.512
					anytime	2	3.041		
	7. never....(15)	*now.......	3	1.335	——	–	——	12	2.046
	8. always...(15)	forever....	2	2.376	——	–	——	11	2.033
		now.......	2	3.831					
	9. seldom...(12)	*often......	3	2.280	never...	2	1.739	7	2.661
	10. often.....(14)	*seldom....	3	1.702	now....	2	2.278	7	3.912
					quick...	2	3.876		

frequent, next most frequent and remaining responses. A star before a most frequent response indicates that it was also the favored response for Group A.

Except in the length of the reaction-times, the results of Groups B and C present comparatively small differences from those of Group A. Of the most frequent responses of Group B, 86.4% are the same as the most frequent responses of Group A. Of the most frequent responses of Group C, 83.1% are the same as those of Group A. The responses of Groups B and C, as was the case in Group A, are predominantly of the same category as their stimulus-words. In the category of numerals, the influence of counting by twos is to be noted; in Group B *four* occurs 4 times as a response to *two*, while in Group C *four* occurs 5 times as a response to *two*, and *six* occurs 4 times as a response to *four*. In both of these groups, *there* occurs as the most frequent response to *where;* the most frequent response of Group A was *when*. The supplementary groups are not large enough, however, to permit us to make comparisons between the results for single words. They do however show us clearly that the associative processes of children and uneducated adults do not differ widely from those of educated adults, except that they are slower. The following tables give the medians of the reaction-times, (a) of the most frequent, (b) next most frequent, and (c) remaining responses to the stimulus words of each of the six categories; at the right of each table are given the medians of the most frequent, next most frequent and remaining reactions of all the categories taken together.

Group B

	Family Names	Adjectives	Numerals	Verbs	Pronouns	Adverbs	Median
(*a*)	1.485	1.454	1.403	2.183	1.698	1.980	1.598
(*b*)	1.924	2.012	2.318	1.914	1.796	1.579	1.914
(*c*)	1.834	1.744	1.681	2.258	2.173	2.355	2.097

Group C

(*a*)	2.042	1.675	1.506	1.770	1.721	1.745	1.702
(*b*)	1.726	1.858	1.988	1.858	2.048	3.041	1.954
(*c*)	2.136	1.814	2.054	1.854	1.992	2.061	2.033

It will be seen from these figures that the reaction-times for children and uneducated adults are longer than those for educated adults. That the times for the next most frequent responses are in many cases longer than those for the infrequent (remaining) responses and in a few cases shorter than the corresponding times for the most frequent responses, is due to the very small number of next most frequent responses (cf. the tables). The number of these being small, the medians represent, not the frequent values of a large group of observers, but the individual peculiarities of two or three observers. In Group A, where many observers were used, the relations of time between most frequent, next most frequent and infrequent reactions are clearly seen.

In discussing the associations of children, Thumb[1] calls attention to the investigation of Ziehen[2] and those of Watt.[3] Of the former investigation, Thumb says, "Wie schon Ziehen an Kindern zwischen 8 und 14 Jahren beobachtet hat, sind Verbal-, d. h. reine Wortassoziationen überhaupt selten; am haüfigsten sind Wörterergänzungen (Post-karte); gelaüfige Wortverbindungen und Reimassoziationen sind sehr viel seltener als bei Erwachsenen; wir sehen also schon hieraus, dass bei Kindern die Bedingungen viel seltener erfüllt sind, die wir für das Zustandekommen von Analogiebildungen voraussetzen müssen: Gelaüfigkeit, Schnelligkeit und Spontaneität der Assoziationen." The investigation of Watt had for its object a direct comparison of the results from children and adults. The stimulus-words used were the same as those which Thumb and Marbe had employed. Of the 8 observers, 5 were children in the second to fifth years of school. The results of this experiment show that the responses of the children are much more scattering than those of the adults; of the responses of the latter, 74% belonged to the class of 'most frequent' reactions; of the responses of the children, only 29% belonged to this class.

A study of Table B will show that the differences between

[1] *Indogerman. Forsch.*, **22**, 43 f.

[2] *Ideenassoziation des Kindes, I, II*, Berlin, 1898, 1900.

[3] *Ztschr. f. Psychol.*, **36**, 417 ff.

the associations of adults and children, found by Ziehen and Watt, do not appear in the results from the English observers —with one exception, namely, the length of the reaction-times. The tables given on pp. 484, 480, show that the association-times for children are longer than those for adults. But in the *character* of the associations, a comparison of the tables of Groups A and B shows a remarkable similarity; thus, 86.4% of the most frequent responses of Group B are the same as the most frequent responses of Group A. The greater *scattering* of the responses which Watt found in children our results do not show at all. Indeed, the scattering is less in the case of the children than in that of the adults. The following table will show what percent of all responses in Group A (educated adults), Group B (children) and Group C (uneducated adults) belong (*a*) to the class of 'most frequent' responses and (*b*) to the classes of 'most frequent' and 'next most frequent' taken together.

	A	*B*	*C*
(*a*)	51.7	58.0	42.8
(*b*)	63.8	67.6	52.9

These figures show that the scattering is greatest in the uneducated adults and least in the children. Of course, it must be borne in mind that Groups B and C are much smaller than Group A; nevertheless, until further and more extended investigations are made, we cannot regard the results of Ziehen and Watt as being of general significance. The significance of the conclusions reached from experiments of this sort is proportional to the number of observers. Until more reliable results are at hand, we are justified in believing that the associations of children are quite similar to those of adults, except in the length of the reaction-time. That there are *more* associations present in the adult than in the child we cannot doubt; but the associations which the child already has are similar to those of the adult.

General Conclusions

1. The rule established by Thumb and Marbe, namely, that the more frequent an association is, the more rapidly

does it take place, is confirmed by the results from the English-speaking observers.

2. In both languages, words of a given category are associated predominantly with words of the same category.

(*a*) In all categories investigated, with the exception of the numerals, reciprocal associations were found. In these cases a word *a* which calls up a word *b* is in turn called up by *b*.

(*b*) Numerals are associated predominantly with higher numerals; the numerals 1–10 are associated predominantly with the *next* higher numeral.

(*c*) Adjectives are associated predominantly with adjectives of opposed meaning.

3. A comparison of the English and German results tends to show that the associations of English- and German-speaking communities correspond in the case of most words which are of familiar meaning and in universal use in both languages.

4. The reaction-times of the associations of children and uneducated adults are longer than those of educated adults, but the favored associations are in most cases the same, and the essential character of the associations is similar.

JUDGMENTS OF FACIAL EXPRESSION AND SUGGESTION

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In an experiment upon the judgment of emotions from facial expressions,[1] in which the subjects attempted to name the emotion depicted in a number of photographs, it was noticed that it was at times possible under suggestion to read various emotions in the face. An experiment was therefore arranged to determine to what degree one is open to suggestion when reading character. It was also the aim of the experiment to bring out, if possible, individual differences in the power of interpretation of facial expression and in suggestibility. The same pictures were used as in the former experiment. Four of the pictures are reproduced in Plate I. These were modified photographs of a talented actor, which appeared in the book by Rudolf entitled 'Der Ausdruck des Menschen.' One hundred and five of the pictures were selected as being the best for the experiment. They covered a wide range of emotions and moods. A few of bodily pain and of the sensations of smelling and tasting, and so forth, were included. Miss Grace Speir conducted the experiment, and tabulated the results. There were five subjects, who were all either members of the advanced experimental course or graduate research students.

The experiment extended throughout the second semester of 1916–1917. Each subject came for one hour a week, and as many pictures as possible were presented in that hour. The subject was shown the picture, and asked to write down his judgment of the expression. After he had done this, he was told either the artist's title of the picture, or an incorrect title, such as 'inspiration' for a picture of 'distrust,' and asked whether he agreed with this title. Some of the incorrect

[1] A report will appear in the *J. of Abnorm. Psychol.*

PLATE I

3

L. 3 F

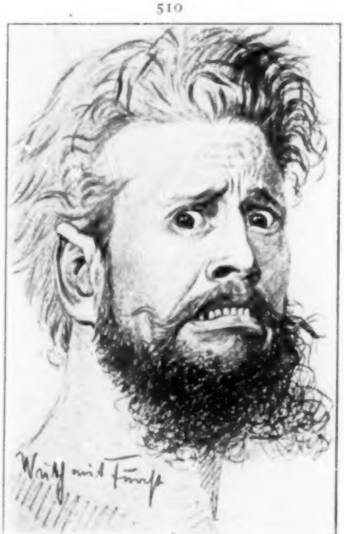
Bedenklichkeit. Kritisch

401

XXV. 1 A

Hohn. Leicht

510



XXVI. 67 A

Wut. Mit Furcht
(leichter Ausdruck)

585

XXIX. 1 F

Lachen.
Bedeutungsvolles Lächeln

FIG. 1. Four of the pictures used. They represent: 3, doubtful, critical; 401, mild scorn; 510, rage with fear; 585, significant smile.

titles were as opposed as possible to the correct title; others were rather similar. The series of one hundred and five pictures was gone through twice. At one presentation the subject was told the correct title, at another presentation the incorrect. On some pictures the correct title was given at the first presentation,—on others at the second presentation, so that the subject never knew, even if he did suspect the purpose of the experiment, whether a right or wrong title was being suggested.

The results are contained in Table I. The various groups of emotions used are shown in the first column. In the second column is the number of tests for each group of emotions. As there are five subjects, these numbers must be divided by five to give the number of pictures in a group; for instance, the scorn-contempt group has 80 judgments and 16 pictures.

The third column shows the number of times the subjects approximated the actual title of the book. An approximated

TABLE I

1 Expression	2 Number of Judgments	3 Book Title Approximated		4 Of Column 3 Book Title Later Approved		5 Of Column 4 Wrong Title Later Suggested and Approved		6 Book Title Not Approximated		7 Of Column 6 Book Title Later Approved		8 Of Column 7 Wrong Title Later Suggested and Approved		9 Total Book Title Approved		10 Total Wrong Title Suggested and Approved	
		%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Scorn-Contempt.	80	36	29	96	28	21	6	64	51	80	41	54	22	86	69	41	28
Misgivings......	65	32	21	100	21	24	5	68	44	63	28	21	6	75	49	23	11
Aversion-Hate...	55	38	21	100	21	42	9	62	34	70	24	62	15	82	45	53	24
Amazement.....	55	58	32	90	29	21	6	42	23	60	14	71	10	78	43	37	16
Laughter........	50	64	32	100	32	31	10	36	18	55	10	70	7	84	42	40	7
Distrust........	45	31	14	92	13	61	8	69	31	54	17	71	12	67	30	67	20
Anger-Rage.....	30	30	9	88	8	0	0	70	21	57	12	25	3	67	20	15	3
Anxiety—Fear-Terror......	25	36	9	88	8	37	3	64	16	68	11	45	5	76	19	42	8
Inspiration......	25	8	2	100	2	100	2	92	23	47	11	64	7	52	13	69	9
Covetousness....	25	4	1	100	1	0	0	96	24	45	11	36	4	48	12	33	4
Wicked-Ill-tempered....	20	15	3	100	3	33	1	85		64	11	45	5	70	14	43	6
Begging-Entreaty	10	10	1	100	1	100	1	90	9	77	7	57	4	80	8	63	5
Bodily Pain.....	10	50	5	100	5	0	0	50	5	40	2	0	0	70	7	0	0
Smelling-Tasting, etc.........	30	37	11	100	11	9	1	63	19	78	15	73	11	87	26	46	12
Average-Total.	525	32	190	97	183	34	52	68	335	61	214	49	111	73	397	41	153

title was taken as a correct judgment because it could not be expected that the subject would frequently use the exact words of the author in describing the picture, so that 'approximated' means 'equivalent.' Throughout this table, the data are presented both in actual amounts and percentages. In the 80 judgments of the scorn and contempt group, for example, 29, or 36%, were correctly approximated. It will be seen that the laughter group was the most readily interpreted, and that amazement comes next. Scorn and contempt, misgiving, aversion and hate, disgust, anger and rage, anxiety, fear, and terror, all of which are more or less related, are interpreted with about the same accuracy. Inspiration, covetousness, wicked and ill-tempered, begging and entreating were poorly interpreted. It was not expected that the sensation groups would give so low a percentage of correct judgments. In this group were also included pictures of sneezing and yawning, and even these were at times incorrectly named. Of the entire 525 judgments a little over a third were correct.

In the fourth column is the number of book titles approved of those which had been already approximated, that is, if we take the scorn-contempt group, the artist's title for 28, or 96%, of the 29 pictures whose titles had been approximated was approved when subsequently shown by the experimenter. These figures give us a check upon the cleverness of the artist in portraying the desired emotions, and it is the data in the fourth column that are used as a basis in determining the suggestibility. A comparison of the totals in columns three and four shows that of the total of 190 such approximations only seven of the artist's titles were not approved when subsequently shown.

The figures in the fifth column show the degree of suggestibility for the various emotions. In the first group, 28 titles were approved. When the wrong titles came to be suggested for these same 28 pictures (after an interval of a month, on an average) six of these wrong titles were accepted. Of the 183 pictures whose titles had been already approved the suggested wrong title was accepted 34% of the time. Excluding the inspiration and begging-entreating groups,

which had only one and two judgments respectively as a basis for calculating the suggestibility, the distrust group offered the greatest opportunity for the effect of suggestibility, and the aversion-hate group was next. With anger and rage, suggestion had no effect.

The sixth column shows the number of times the subjects were unsuccessful at approximating the picture. These numbers are complements of the figures in column three.

Column seven gives the number of artist's titles which were approved of those pictures which the subjects themselves had previously not approximated. For instance, in the first group, of the 51 pictures which had not been approximated, the subjects approved 41 of the book titles. As was to be expected, fewer of the artist's titles were approved of these non-approximated pictures than of the approximated ones; in all only 61%, as against 97% of the approximated titles. This drop is indicative of the artist's failure to reproduce the expression he desired. The pictures that were not approximated, even though the artist's titles were approved, gave more room for suggestion than the approximated pictures. 49% of the suggested wrong titles of the 214 approved, non-approximated titles were accepted as against 34% of the 183 approved and approximated. This means that if the subject had not himself judged the title correctly, even though he agreed with the title that the artist gave, he was more open to subsequent suggestion than when he had judged the title correctly in the first place. Distrust is again high in suggestibility. The suggestibility in amazement is as high as in distrust, and in laughter almost as high.

In the next to the last column is the sum of all the book titles which are approved whether they had previously been approximated or not, and is obtained by adding columns seven and four.

In the last column is the total amount of suggestibility with the pictures from which the figures of the previous column were obtained, that is, the total amount of suggestibility whether the titles had previously been approximated or not. Of the total number of 397 titles approved, 153 or 41% offered opportunity for suggestion.

Table II shows individual differences both in the ability to judge emotions and in suggestibility. In the first horizontal line are the five subjects A, B, C, D, and E.

TABLE II

Subject	A		B		C		D		E	
	%	No.	%	No.	%	No.	%	No.	%	No.
Book title approximated	55	58	30	31	39	41	29	31	17	18
Of last, book title later approved	97	56	90	28	88	36	100	31	94	17
Of last, wrong title later suggested and approved	29	16	32	9	31	11	16	5	47	8
Book title not approximated	45	47	70	74	61	64	70	74	83	87
Of last, book title later approved	68	32	58	43	53	36	47	35	92	80
Of last, wrong title later suggested and approved	34	11	46	20	44	16	31	11	69	55
Total: book title approved	84	88	68	71	69	72	63	66	92	97
Total: wrong title suggested and approved	31	27	41	29	37	27	24	16	65	63

In the second horizontal line are the number and percentage of the book titles approximated by each subject. Subject A is the best and subject E the worst in correctly interpreting facial expressions. In order of merit they rank A, C, B, D, E.

The third horizontal line shows the number of book titles which had been previously approximated, and which were approved by the various subjects. For example, A approximated 58, or 55% of the total number. This column offers no new facts, but is used as a basis for calculating the amount of suggestibility which is shown in the next column.

Here it will be seen that subject E is the most suggestible having accepted 47% of the titles suggested with pictures whose correct titles he had approved; that is, when he was given incorrect titles in connection with the 17 pictures whose correct titles he had previously approved, he accepted eight of them. Subject D was the least suggestible. The ranking of the subjects in suggestibility is E, B, C, A and D.

In the fifth horizontal line is the number of book titles which the subjects did not approximate. This is the complement of the results in the second horizontal line. Therefore the ranking by subjects is the reverse of that of the second horizontal line.

In the sixth horizontal line is the number of book titles which were approved of those which had previously not been approximated. It is seen that subject E is the least discriminating, accepting almost every title shown him, that is, 80 or 90% of the titles suggested for the 87 pictures, previously not approximated. In this group of pictures whose titles were not approximated there are, of course, a great many pictures which very poorly portray the emotion intended. Undoubtedly, when the book titles were subsequently given, some of these which are really inappropriate were accepted through suggestion. If we rank the subjects according to the number of those book titles which they accepted, we shall see that the order closely correlates with that of the ranking according to suggestibility; the most highly suggestible accepting the most titles, and the least suggestible accepting the fewest. Inasmuch as subject E is also the most suggestible to wrong titles, it may be said that he accepts almost anything given him whether right or wrong.

The seventh horizontal line shows the amount of suggestibility to these non-approximated titles according to subjects It will be remembered from the first table where the results of the five subjects were averaged, that there was more suggestibility in the cases where the book title was not approximated. The figures of this line show that this is sc in the case of each individual subject. The ranking according to suggestibility is the same as that previously shown with the approximated titles, being subjects E, B, C, A, D.

The last two horizontal lines present the average of the results of the approximated and non-approximated groups and offer no new facts.

It may be said that by this experiment decided individual differences have been shown among the five subjects in regard to suggestibility and ability to read facial expression. It is evident that subject E has very little ability in reading faces, and is highly suggestible, accepting 65% of the wrong titles shown him, as well as 92% of the book titles, some of which were decidedly poor according to the other subjects. It was discovered from other unrelated experiments and from the

subject's own report that he had little if any visual imagery, and that he felt entirely at sea when asked to make a judgment of emotions visually expressed. It does not follow, however, because one is unable to make correct judgments that one is highly suggestible, and will accept any title offered. Subject D, for instance, ranks next to E in inability to interpret correctly the emotions, but he accepts the fewest wrong titles. He also rejects the greatest number of titles in the non-approximated group. There is a suspicion that he is of the negatively suggestible type. The fact that he accepted all the book titles in the approximated group when they were read to him, subsequent to his judgment, does not contradict this, as he was here accepting titles similar to those that he himself had already made. Nor does it follow that the subject who gives the greatest number of correct judgments is the least suggestible. Subject A is more suggestible than subject D, although he has the greatest number of correct judgments. The other subjects, B and C, hold a middle place in regard to both correct judgments and suggestibility.

The results of this experiment seemed sufficiently encouraging to warrant the devising of a test along these lines. With this purpose fourteen of the best pictures have been selected.[1] The titles of these pictures have been approved by at least four of the five subjects. It is now the intention to test with them a larger number of subjects.

[1] These pictures can be obtained from the author, at cost, by anyone who desires to use them.

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